Technical Report CERC-95-10
July 1995

US Army Corps of Engineers
Waterways Experiment Station

Annual Data Summary for 1992 CERC Field Research Facility

Volume I: Main Text and Appendices A and B

by Michael W. Leffler, Clifford F. Baron, Brian L. Scarborough, Kent K. Hathaway, Paul R. Hodges, C. Ray Townsend

Prepared for Headquarters, U.S. Army Corps of Engineers

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Final Report

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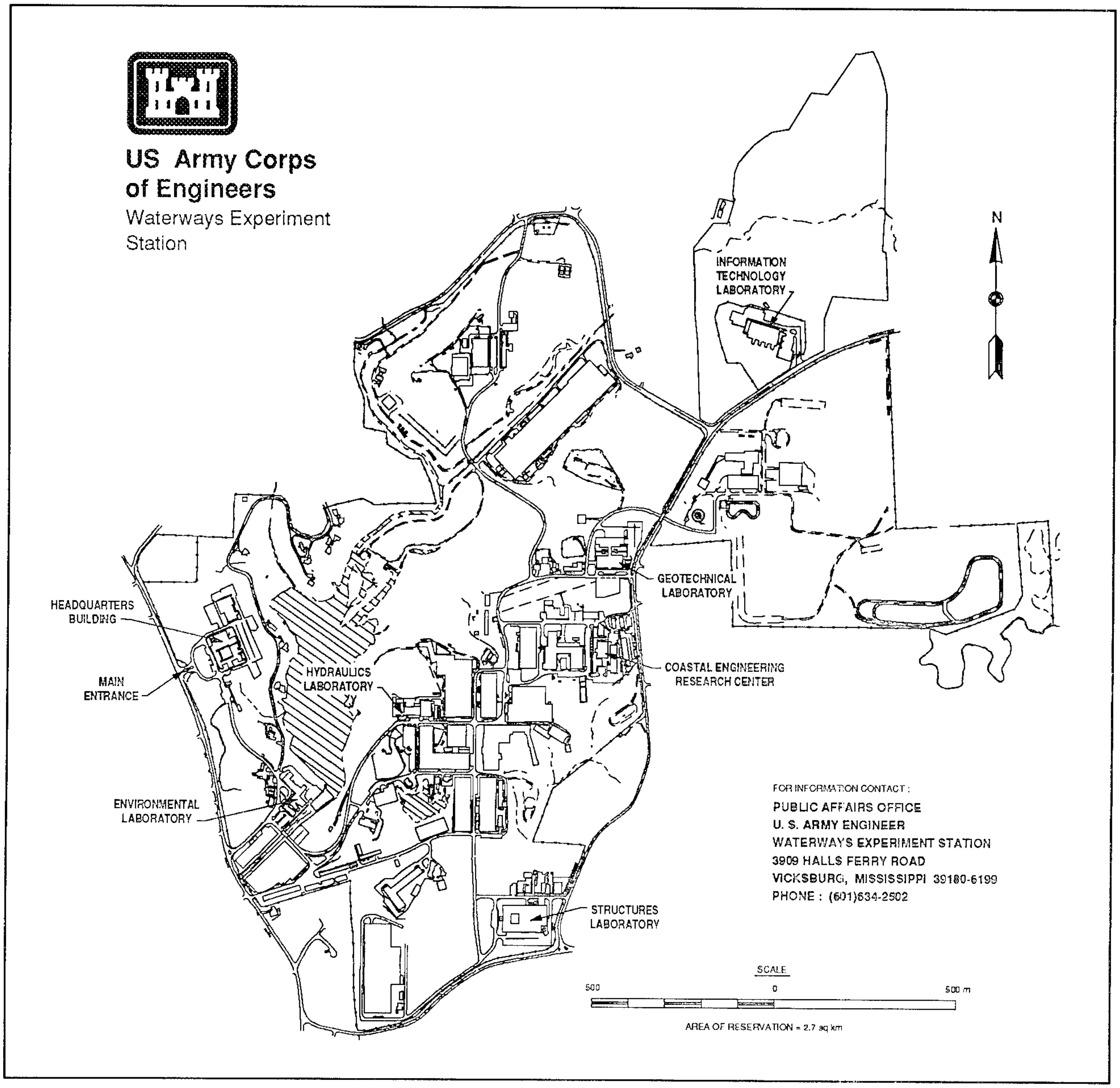
Prepared for U.S. Army Corps of Engineers
Washington, DC 20314-1000



Waterways Experiment Station Cataloging-in-Publication Data

Annual data summary for 1992, CERC Field Research Facility / by Michael W. Leffler ... [et al.] ; prepared for U.S. Army Corps of Engineers.

2 v. : ill. ; 28 cm. -- (Technical report ; CERC-95-10)

Includes bibliographic references.

v. 1. Main text and appendixes A and B--v. 2. appendixes C through E.

1. Ocean waves -- North Carolina -- Statistics. 2. Water waves -- North Carolina -- Duck -- Statistics. 3. Oceanographic research stations -- North Carolina -- Duck. 4. Oceanography -- North Carolina -- Duck -- Statistics. I. Leffler, Michael W. II. United States. Army. Corps of Engineers. III. U.S. Army Engineer Waterways Experiment Station. IV. Coastal Engineering Research Center (U.S. Army Engineer Waterways Experiment Station) V. Series: Technical report (U.S. Army Engineer Waterways Experiment Station) ; CERC-95-10.

TA7 W34 no.CERC-95-10

Contents

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[1] A limited number of copies of Appendixes C-E (Volume II) were published under separate cover. Copies are available from National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161.

Preface

This report is the 14th in a series of annual data summaries authorized by Headquarters, US Army Corps of Engineers (HQUSACE), under Civil Works Research Work Unit 32525, "Field Research Facility Analysis", Coastal Flooding Program. Funds were provided through the US Army Engineer Waterways Experiment Station (WES), Coastal Engineering Research Center (CERC), under the program management of Ms. Carolyn M. Holmes, CERC. The HQUSACE Technical Monitors were Messrs. John H. Lockhart, Jr.; Barry Holliday; John G. Housley; and David Roellig.

The data for the report were collected and analyzed at the WES/CERC Field Research Facility (FRF) in Duck, NC. The report was prepared by Mr. Michael W. Leffler, FRF, under the direct supervision of Mr. William A. Birkemeier, Chief, FRF Group, Engineering Development Division (EDD), and Mr. Thomas W. Richardson, Chief, EDD; and under the general supervision of Dr. James R. Houston and Mr. Charles C. Calhoun, Jr., Director and Assistant Director, CERC, respectively. Mr. Kent K. Hathaway, FRF, assisted with instrumentation, and Mr. Brian L. Scarborough, FRF, assisted with data collection. Messrs. Clifford F. Baron, Stuart Holme, Guan-hong Lee, and Jonathan J. Lee, and Mses. Judy H. Roughton and Sharon Nearhoof assisted with data analysis at the FRF. Additional assistance was provided by Ms. Dawn S. Miller, FRF. The National Oceanic and Atmospheric Administration/National Ocean Service maintained the tide gage and provided statistics for summarization.

At the time of publication of this report, Director of WES was Dr. Robert W. Whalin. Commander was LTC(P) Bruce K. Howard, EN.

1 Introduction

Background

The U.S. Army Engineer Waterways Experiment Station (WES), Coastal Engineering Research Center's (CERC's) Field Research Facility (FRF), located on 0.7 km^2 at Duck, NC (Figure 1), consists of a 561-m-long research pier and accompanying office and field support buildings. The FRF is located near the middle of Currituck Spit along a 100-km unbroken stretch of shoreline extending south of Rudee Inlet, VA, to Oregon Inlet, NC. The FRF is bordered by the Atlantic Ocean to the east and Currituck Sound to the west. The facility is designed to (a) provide a rigid platform from which waves, currents, water levels, and bottom elevations can be measured, especially during severe storms; (b) provide CERC with field experience and data to complement laboratory and analytical studies and numerical models; (c) provide a manned field facility for testing new instrumentation; and (d) serve as a permanent field base of operations for physical and biological studies of the site and adjacent region.

The research pier is a reinforced concrete structure supported on 0.9-m-diam steel piles spaced 12.2 m apart along the pier's length and 4.6 m apart across the width. The piles are embedded approximately 20 m below the ocean bottom. The pier deck is 6.1 m wide and extends from behind the duneline to about the 6-m water depth contour at a height of 7.8 m above the National Geodetic Vertical Datum (NGVD). The pilings are protected against sand abrasion by concrete erosion collars and against corrosion by a cathodic system.

An FRF Measurements and Analysis Program has been established to collect basic oceanographic and meteorological data at the site, reduce and analyze these data, and publish the results.

This report, which summarizes data for 1992, continues a series of reports begun in 1977.

Organization of Report

This report is organized into nine Chapters and five appendixes. Chapter 1 is an introduction; Chapters 2 through 8 discuss the various data collected during the year; and Chapter 9 describes the storms that occurred. Appendix A presents the bathymetric surveys, Appendix B summarizes deepwater wave statistics, and Appendixes C through E (published under separate cover as Volume II) contain summary statistics for other gages.

In each Chapter of this report, the respective instruments used for monitoring the meteorological or oceanographic conditions are briefly described, along with data collection and analysis procedures

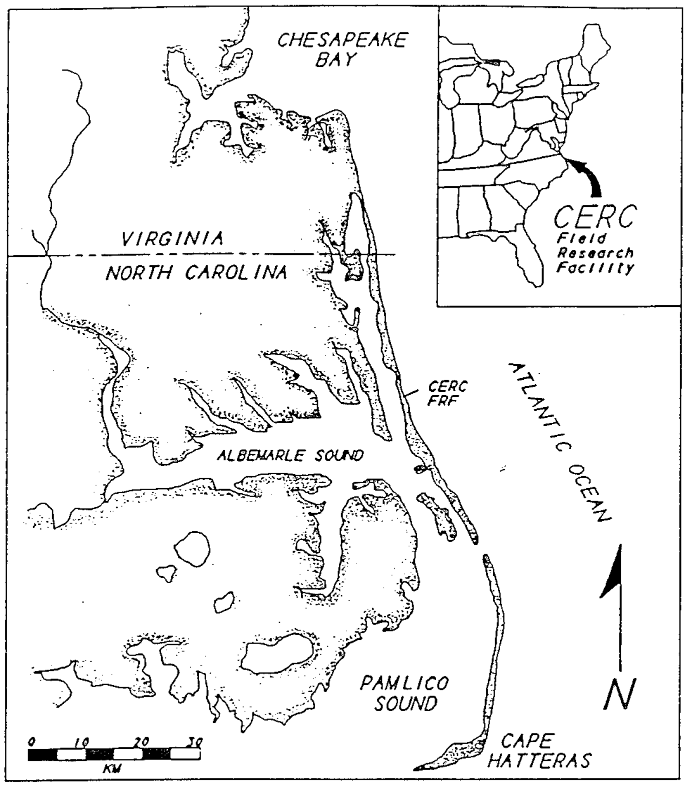

Figure 1. FRF location map

and data results. The instruments were interfaced with the primary data acquisition system, a Digital Equipment Corporation (Maynard, MA) VAX-11/750 minicomputer located in the FRF laboratory building. More detailed explanations of the design and the operation of the instruments may be found in Miller (1980). Readers' comments on the format and usefulness of the data presented are encouraged.

Availability of Data

Table 1 summarizes the available data. In addition to the wave data summaries in the main text, more extensive summaries for each of the wave gages are provided in Appendixes B through E.

The annual data summary herein summarizes daily observations by month and year to provide basic data for analysis by users. Daily measurements and observations have already been reported in a series of monthly Preliminary Data Summaries (FRF 1992). If individual data for the present year are needed, the user can obtain detailed information (as well as the monthly and previous annual reports) from the following address:

USAE Waterways Experiment Station
Coastal Engineering Research Center
Field Research Facility
1261 Duck Rd.
Kitty Hawk, NC 27949-4472

Table 1
1992 Data Availability

	Gage ID	Jan 1 2 3 4 5	Feb 1 2 3 4	Mar 1 2 3 4	Apr 1 2 3 4 5	May 1 2 3 4	Jun 1 2 3 4	Jul 1 2 3 4 5	Aug 1 2 3 4	Sep 1 2 3 4	Oct 1 2 3 4 5	Nov 1 2 3 4	Dec 1 2 3 4
Weather													
Anemometer	932	* * * * *	* * * *	/ * * *	* * * * *	* * * *	* * * *	* * * * *	* * * *	* * / *	* * * * *	* * * *	* * * *
Atmospheric Pres.	616	* * * * *	* * * *	/ * * *	* * * * *	* * * *	* * * *	* * * * *	* * * *	* * / *	* * * * *	* * * *	* * * *
Air Temperature	624	* * * * *	* * * *	/ * * *	* * * * *	* * * *	* * * *	* * * * *	* / / *	* * / *	* * * * *	* * * *	* * * /
Precipitation	604	* * * * *	* * * *	/ * * *	* * * * *	* * * *	* * * *	* * * * *	* * * *	* * / *	* * * * *	* * * *	* * * *
Waves													
Offshore Waverider	630	- - - - -	- - - -	/ * * *	/ * * * *	* * * *	* * * /	* * / * *	* / * *	* * / /	* * * * *	* * * *	* * * *
Pressure Gage	111	* * * * *	* * * *	/ * * *	* * * * *	* * * *	* * * *	* * * * *	* * * /	* * / *	* * * * *	* * * *	* * * *
Pier End	625	* * * * *	* * * *	/ * * *	* * * * *	* * * *	* * * *	* * * * *	* * * *	* * / *	* * * * *	* * * *	* * * *
Pier Nearshore	645	* * * * *	* * * *	/ * * *	* * * * *	* * * *	* * * *	* * * * *	* * * *	* * / *	* * * * *	* * * *	* * * *
Currents													
Pier End		* * * * *	* * * *	* * * *	* * * * *	* * * *	* * * *	* * * * *	* * * *	* * * *	* * * * *	* * * *	* * * *
Pier Nearshore		* * * * *	* * * *	* * * *	* * * * *	* * * *	* * * *	* * * * *	* * * *	* * * *	* * * * *	* * * *	* * * *
Beach		* * * * *	* * * *	* * * *	* * * * *	* * * *	* * * *	* * * * *	* * * *	* * * *	* * * * *	* * * *	* * * *
Pier End Tide Gage		/ * * * *	* * * *	* / * *	* * * * *	* * * *	/ / * *	* * * * *	* * * /	* / / *	/ * * * *	* * * *	* * * *
Water Characteristics													
Temperature		* * * * *	* * * *	* * * *	* * * * *	* * * *	* * * *	* * * * *	* * * *	* * * *	* * * * *	* * * *	* * * *
Visibility		* * * * *	* * * *	* * * *	* * * * *	* * * *	* * * *	* * * * *	* * * *	* * * *	* * * * *	* * * *	* * * *
Density		* * * * *	* * * *	* * * *	* * * * *	* * * *	* * * *	* * * * *	* * * *	* * * *	* * * * *	* * * *	* * * *
Bathymetric Surveys		week 4: *	week 4: *	week 4: *	week 4: *	week 2: *	week 4: *		week 2: *	week 1: *	week 5: *		
Photography													
Beach		* * * * *	* * * *	* * * *	* * * * *	* * * *	* * * *	* * * * *	* * * *	* * * *	* / - - /	* * * *	* * / *
Aerial		week 3: *						week 3: *					

Notes: * Full week of data obtained.
/ Less than 7 days of data obtained.
- No data obtained.

Although the data collected at the FRF are designed primarily to support ongoing CERC research, use of the data by others is encouraged. Tidal data other than the summaries in this report can be obtained directly from the following address:

National Oceanic and Atmospheric Administration
National Ocean Service
ATTN: Tide Analysis Branch
Rockville, MD 20852

A complete explanation of the exact data desired for specific dates and times will expedite filling any request; an explanation of how the data will be used will help CERC or the National Oceanic and Atmospheric Administration (NOAA)/National Ocean Service (NOS) determine whether other relevant data are available. For information regarding the availability of data for all years, contact the FRF at (919) 261-3511. Costs for collecting, copying, and mailing will be borne by the requester.

2 Meteorology

This chapter summarizes the meteorological measurements made during the current year and in combination with all previous years. Meteorological measurements during storms are given in Chapter 9.

Mean air temperature, atmospheric pressure, and wind speed and direction were computed for each data file, which consisted of data sampled two times per second for 34 min every 6 hr beginning at or about 0100, 0700, 1300, and 1900 hr eastern standard time (EST); these hours correspond to the time that the National Weather Service (NWS) creates daily synoptic weather maps. During storms, data recordings were made more frequently. Meteorological data are summarized in Table 2.

Table 2
Meteorological Statistics

	Mean Air Temperature deg C		Mean Atmospheric Pres. mb		Precipitation, mm				Wind Resultants			
					1992	1978-1992			1992		1980-1992	
Month	1992	1983-1992	1992	1983-1992	Total	Mean	Maxima	Minima	Speed m/sec	Direction deg	Speed m/sec	Direction deg
Jan	7.5	6.1	1013.6	1017.6	117	101	180	44	1.5	301	2.2	331
Feb	8.4	6.9	1014.2	1017.2	38	71	113	20	2.1	14	1.7	345
Mar	9.1	9.6	1013.2	1016.0	66	99	206	35	1.1	308	1.3	352
Apr	13.8	13.7	1014.5	1013.9	10	94	182	0	0.1	140	0.3	328
May	15.8	18.9	1015.1	1015.8	66	72	239	20	3.2	34	0.3	164
Jun	22.0	23.6	1011.6	1015.1	53	86	136	27	1.5	101	0.9	191
Jul	26.6	26.4	1013.4	1015.9	129	101	275	19	3.0	210	1.9	210
Aug	24.8	25.8	1016.5	1016.1	253	110	253	30	0.9	99	0.5	97
Sep	22.9	22.8	1017.8	1017.7	100	77	226	5	3.1	40	2.0	40
Oct	16.0	18.0	1016.1	1018.9	31	69	143	17	2.0	12	2.3	25
Nov	13.7	13.6	1018.3	1018.2	138	91	145	26	1.4	17	1.6	346
Dec	9.7	8.2	1017.6	1019.4	61	66	131	4	2.8	330	2.2	328
Average	15.9	16.1	1015.2	1016.9	89	86			0.9	13	0.8	353
Total					1062	1037						

Air Temperature

The FRF enjoys a typical marine climate that moderates the temperature extremes of both summer and winter.

Measurement instruments

A Yellow Springs Instrument Company, Inc. (YSI) (Yellow Springs, OH), electronic temperature probe with analog output interfaced to the FRF's computer was operated beside the NWS's meteorological instrument shelter located 43 m behind the dune (Figure 2). To ensure proper temperature readings, the probe was installed 3 m above ground inside a "coolie hat" to shade it from direct sun, yet provide proper ventilation.

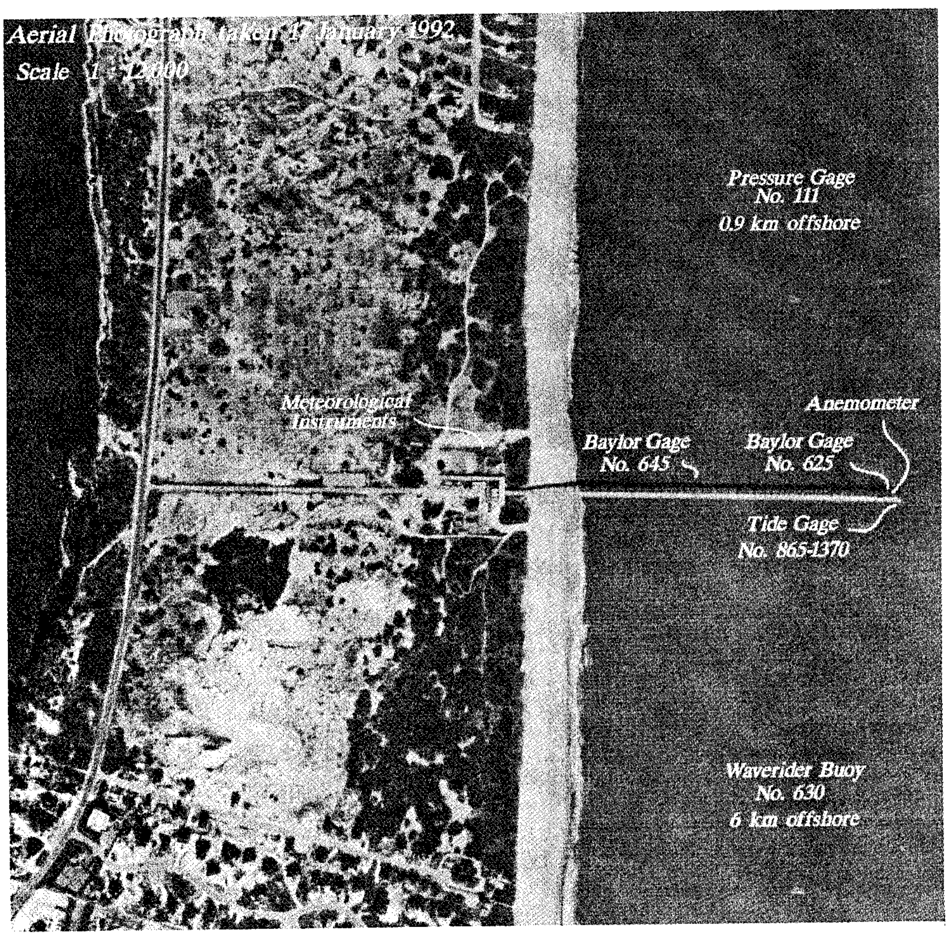

Figure 2. FRF gage locations

Results

Daily and average air temperature values are tabulated in Table 2 and shown in Figure 3.

Atmospheric Pressure

Measurement instruments

Electronic atmospheric pressure sensor. Atmospheric pressure was measured with a YSI electronic sensor with analog output located in the laboratory building at 9 m above NGVD. Data were recorded on the FRF computer. Data from this gage were compared with those from an NWS aneroid barometer to ensure proper operation.

Microbarograph. A Weathertronics, Incorporated (Sacramento, CA), recording aneroid sensor (microbarograph) located in the laboratory building also was used to continuously record atmospheric pressure variation.

The microbarograph was compared daily with the NWS aneroid barometer, and adjustments were made as necessary. Maintenance of the microbarograph consisted of inking the pen, changing the chart paper, and winding the clock every 7 days. During the summer, a meteorologist from the NWS checked and verified the operation of the barometer.

The microbarograph was read and inspected daily using the following procedure:

a. The pen was zeroed (where applicable).
b. The chart time was checked and corrected, if necessary.
c. The daily reading was marked on the chart for reference.
d. The starting and ending chart times were recorded, as necessary.
e. New charts were installed, when needed.

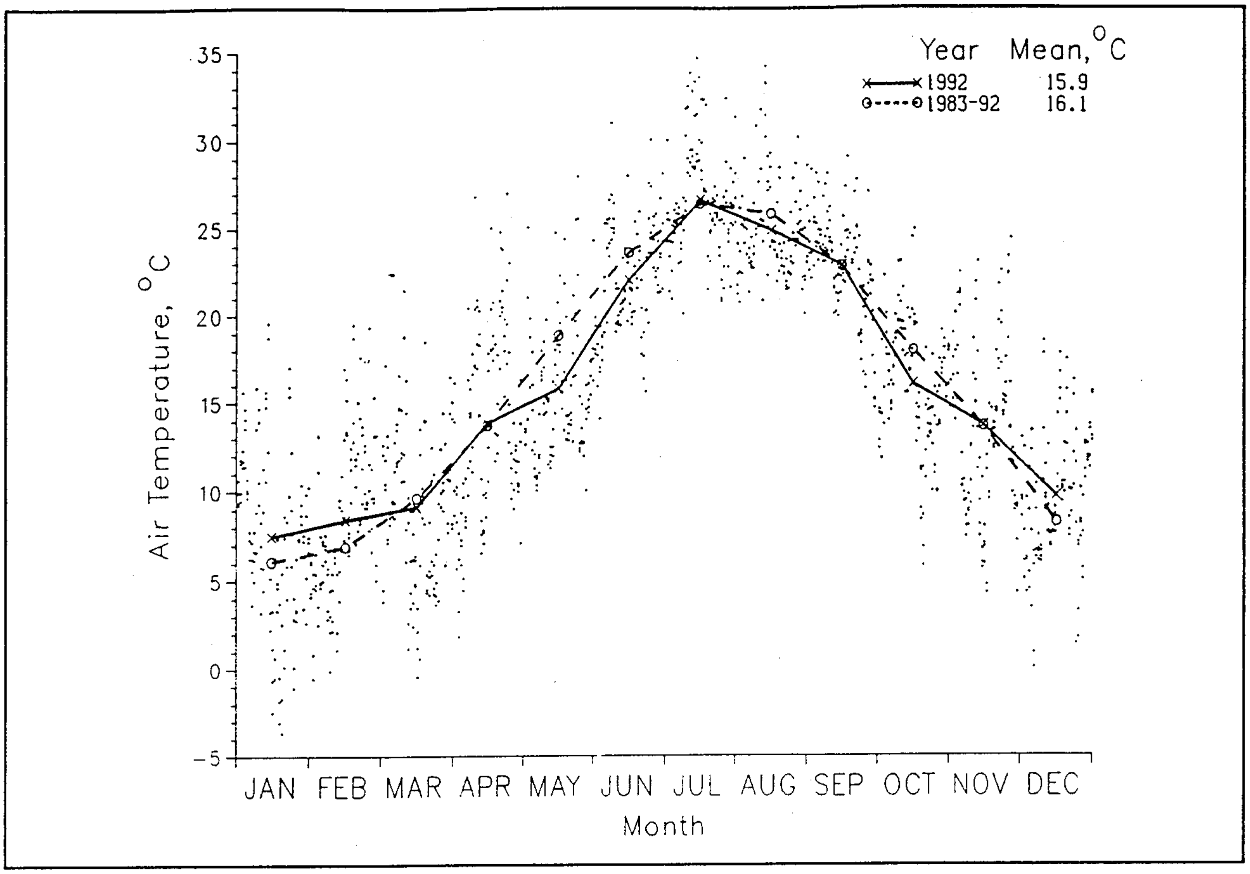

Figure 3. Daily air temperature values with monthly means

Results

Daily and average atmospheric pressure values are presented in Figure 4, and summary statistics are presented in Table 2.

Precipitation

Precipitation is generally well distributed throughout the year. Precipitation from mid-latitude cyclones (northeasters) predominates in the winter, whereas local convection (thunderstorms) accounts for most of the summer rainfall.

Measurement instruments

Electronic rain gage. A Belfort Instrument Company (Baltimore, MD) 30-cm weighing rain gage, located near the instrument shelter 47 m behind the dune, measured daily precipitation. According to the manufacturer, the instrument's accuracy was 0.5 percent for precipitation amounts less than 15 cm and 1.0 percent for amounts greater than 15 cm.

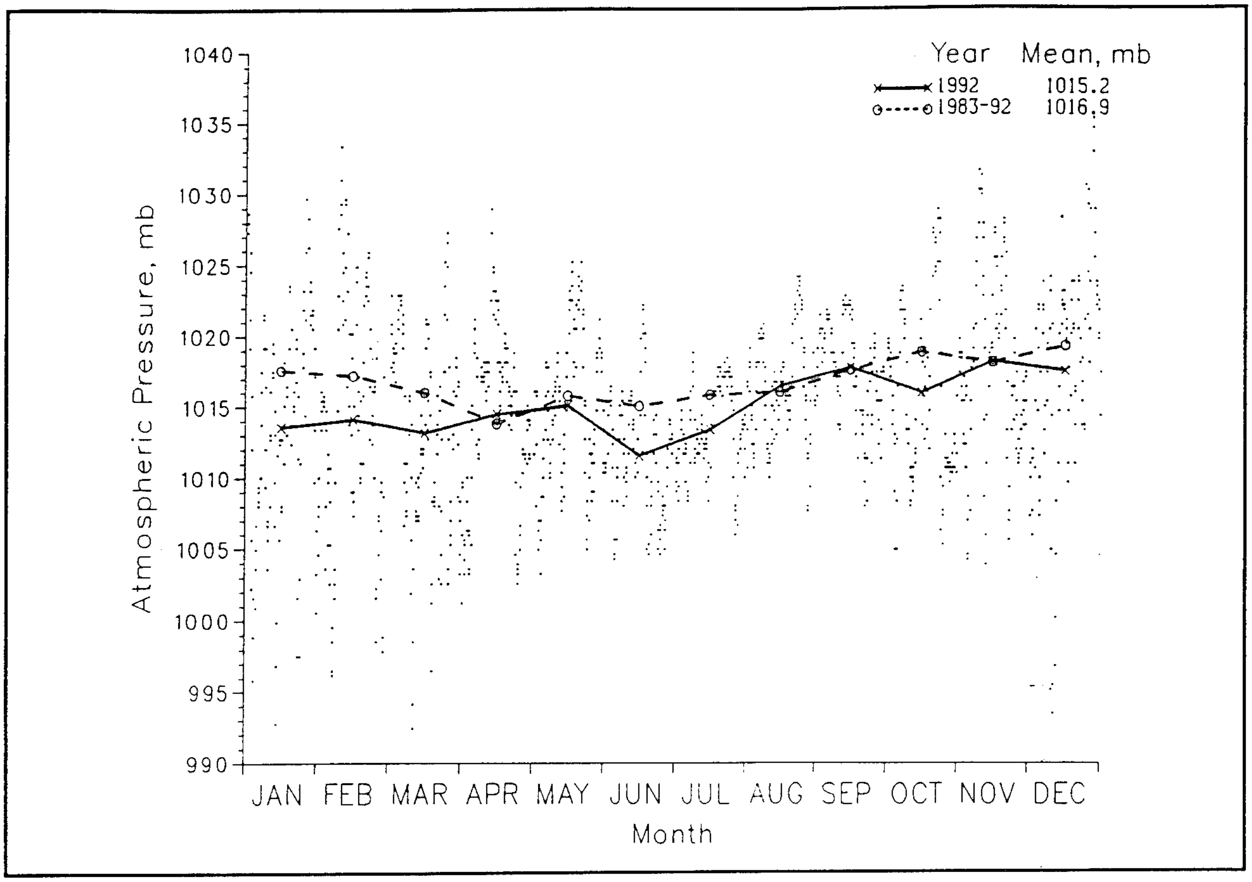

Figure 4. Daily barometric pressure values with monthly means

The rain gage was inspected daily, and the analog chart recorder was maintained by procedures similar to those for the microbarograph.

Plastic rain gage. An Edwards Manufacturing Company (Alberta Lea, MN) True Check 15-cm-capacity clear plastic rain gage with a 0.025-cm resolution was used to monitor the performance of the weighing rain gage. This gage was located near the weighing gage, and the gages were compared on a daily basis. Very few discrepancies were identified during the year.

Results

Daily and monthly average precipitation values are shown in Figure 5. Statistics of total precipitation for each month during this year and average totals for all years combined are presented in Table 2.

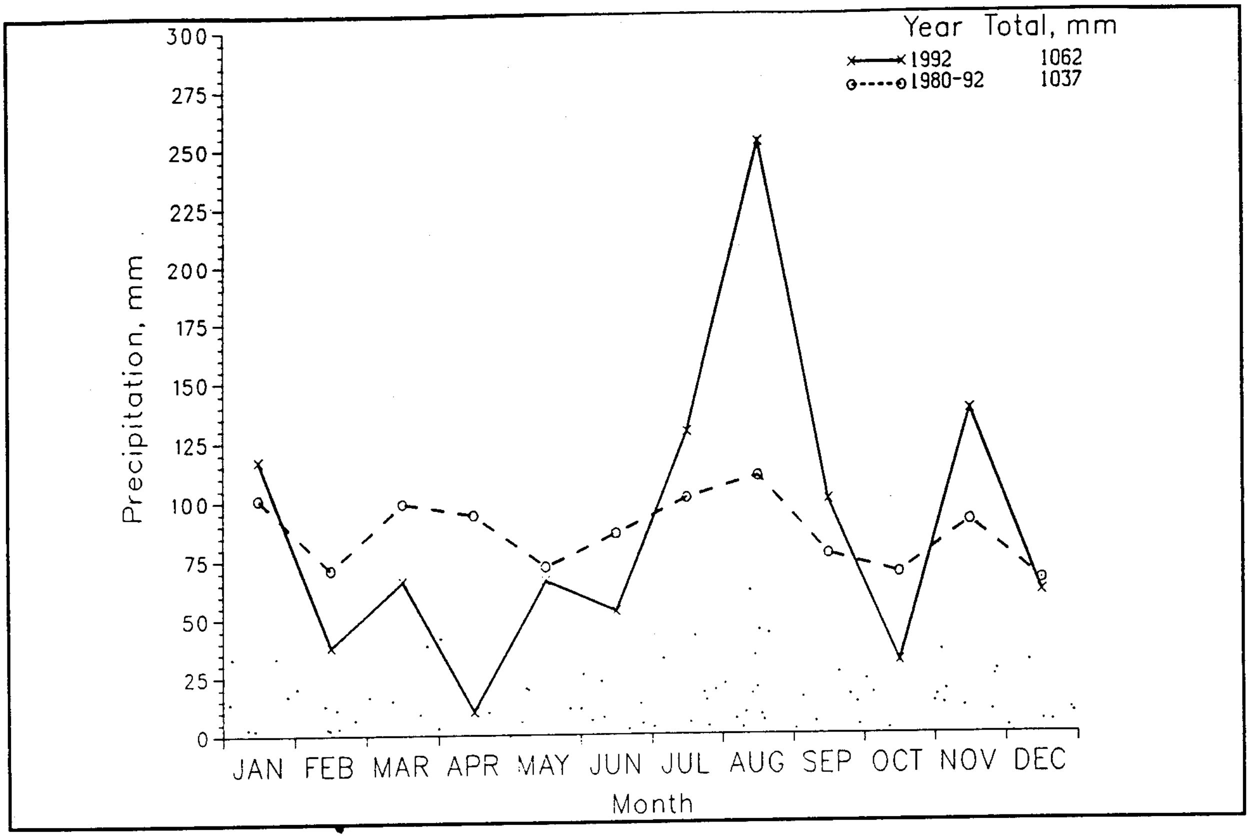

Figure 5. Daily precipitation values with monthly totals

Wind Speed and Direction

Winds at the FRF are dominated by tropical maritime air masses that create low to moderate, warm southern breezes; arctic and polar air masses that produce cold winds from northerly directions; and smaller scale cyclonic, low pressure systems, which originate either in the tropics (and move north along the coast) or on land (and move eastward offshore). The dominant wind direction changes with the season, being generally from northern directions in the fall and winter and from southern directions in the spring and summer. It is common for fall and winter storms (northeasters) to produce winds with average speeds in excess of 15 m/sec.

Measurement instrument

Winds were measured at the seaward end of the pier at an elevation of 19.1 m (Figure 2) using a Weather Measure Corporation (Sacramento, CA) Skyvane Model W102P anemometer. Wind speed and direction data were collected on the FRF computer. The anemometer manufacturer specifies an accuracy of $\pm$0.45 m/sec below 13 m/sec and 3 percent at speeds above 13 m/sec, with a threshold of 0.9 m/sec. Wind direction accuracy is $\pm$2 deg, with a resolution of less than 1 deg. The anemometer is calibrated annually at the National Bureau of Standards in Gaithersburg, MD, and is within the manufacturer's specifications.

Results

Annual and monthly joint probability distributions of wind speed versus direction were computed. Wind speeds were resolved into 3-m/sec intervals, whereas the directions were at 22.5-deg intervals (i.e., 16-point compass direction specifications). These distributions are presented as wind "roses," such that the length of the petal represents the frequency of occurrence of wind blowing from the specified direction, and the width of the petal is indicative of the speed. Resultant directions and speeds were also determined by vector-averaging the data (see Table 2). Wind statistics are presented in Figures 6-8.

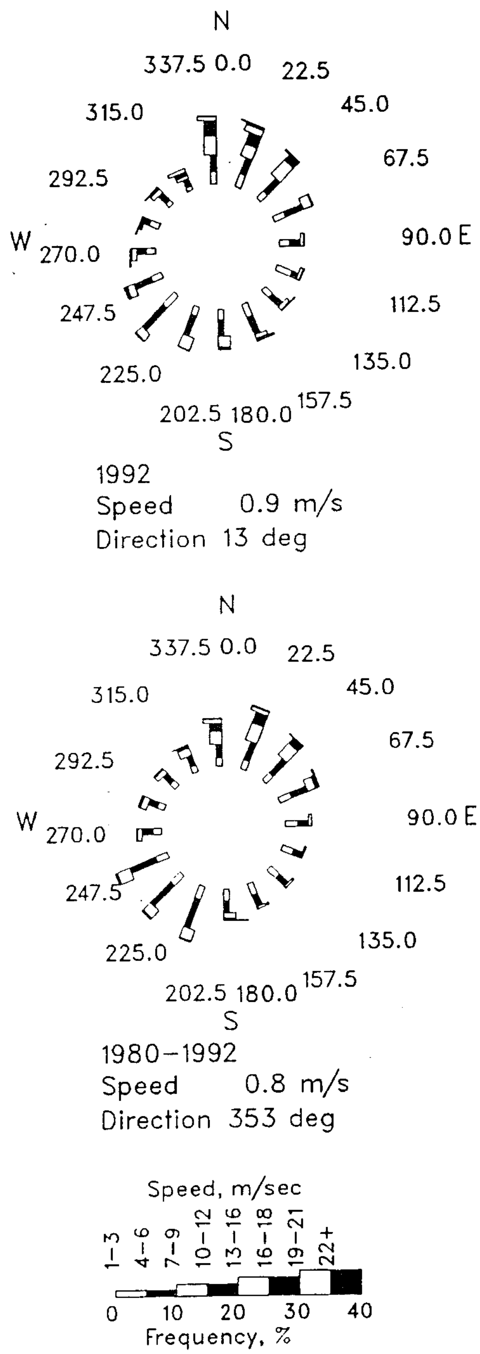

Figure 6. Annual wind roses

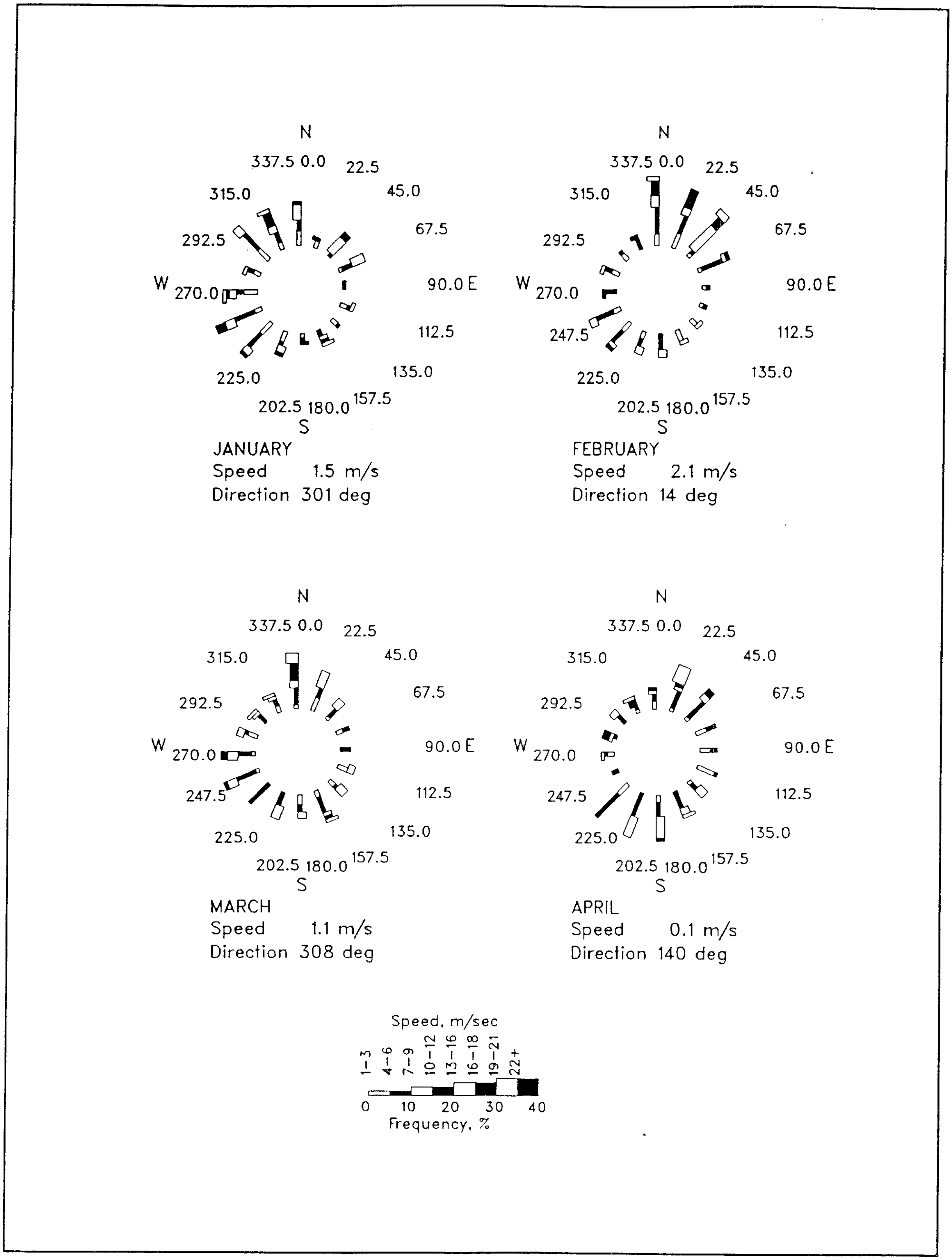

Figure 7. Monthly wind roses for 1992 (Continued)

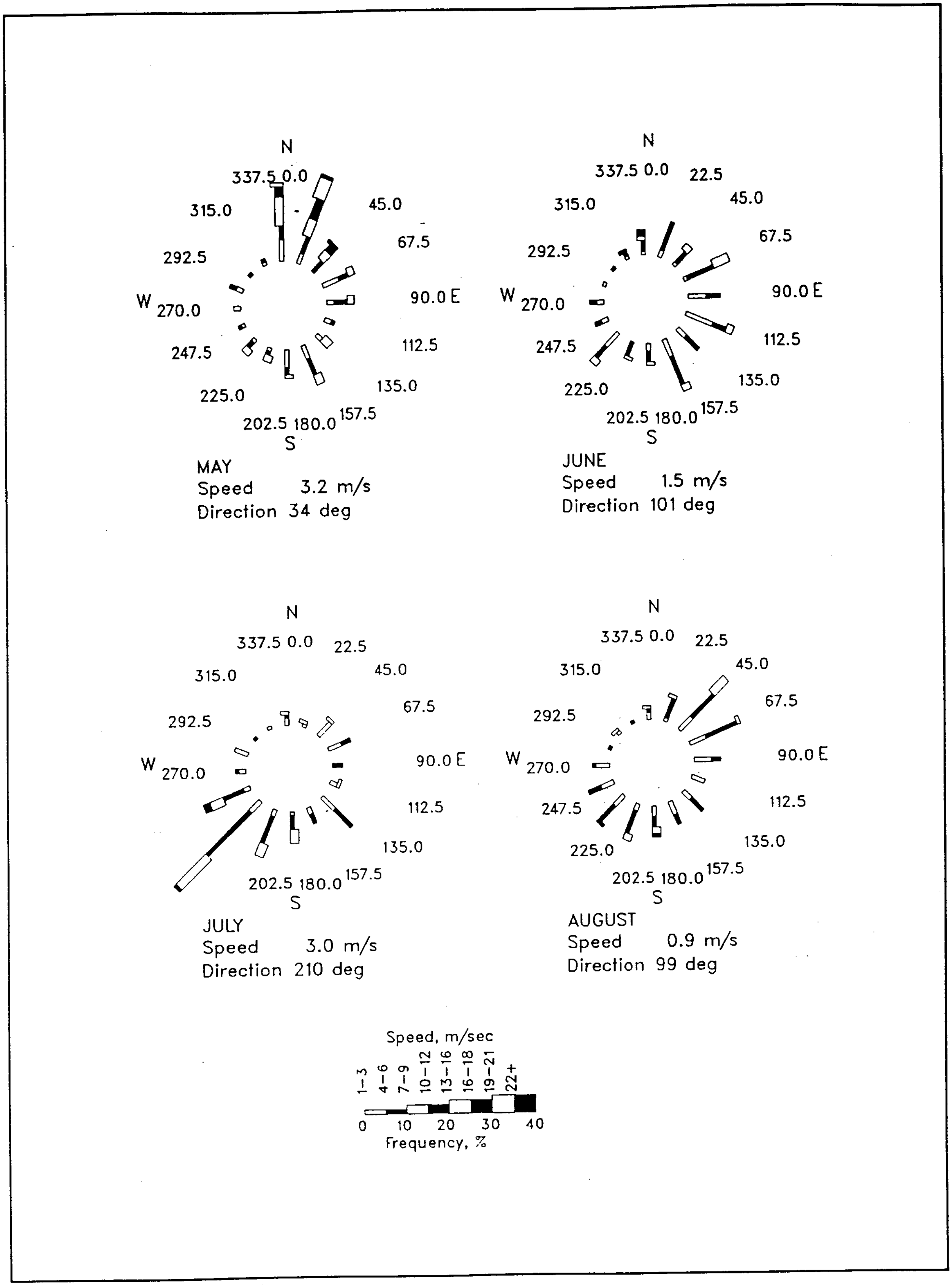

Figure 7. (Continued)

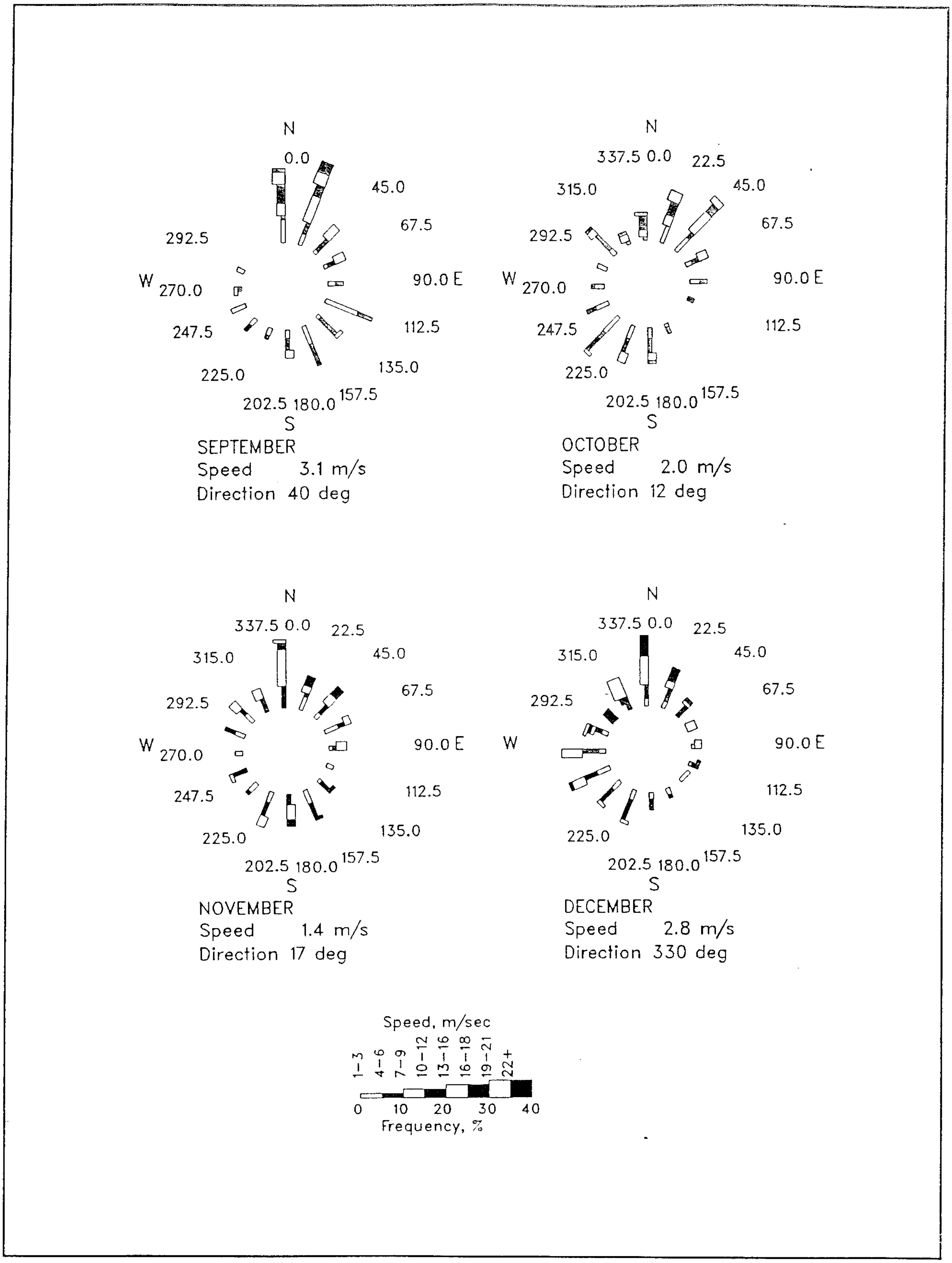

Figure 7. (Concluded)

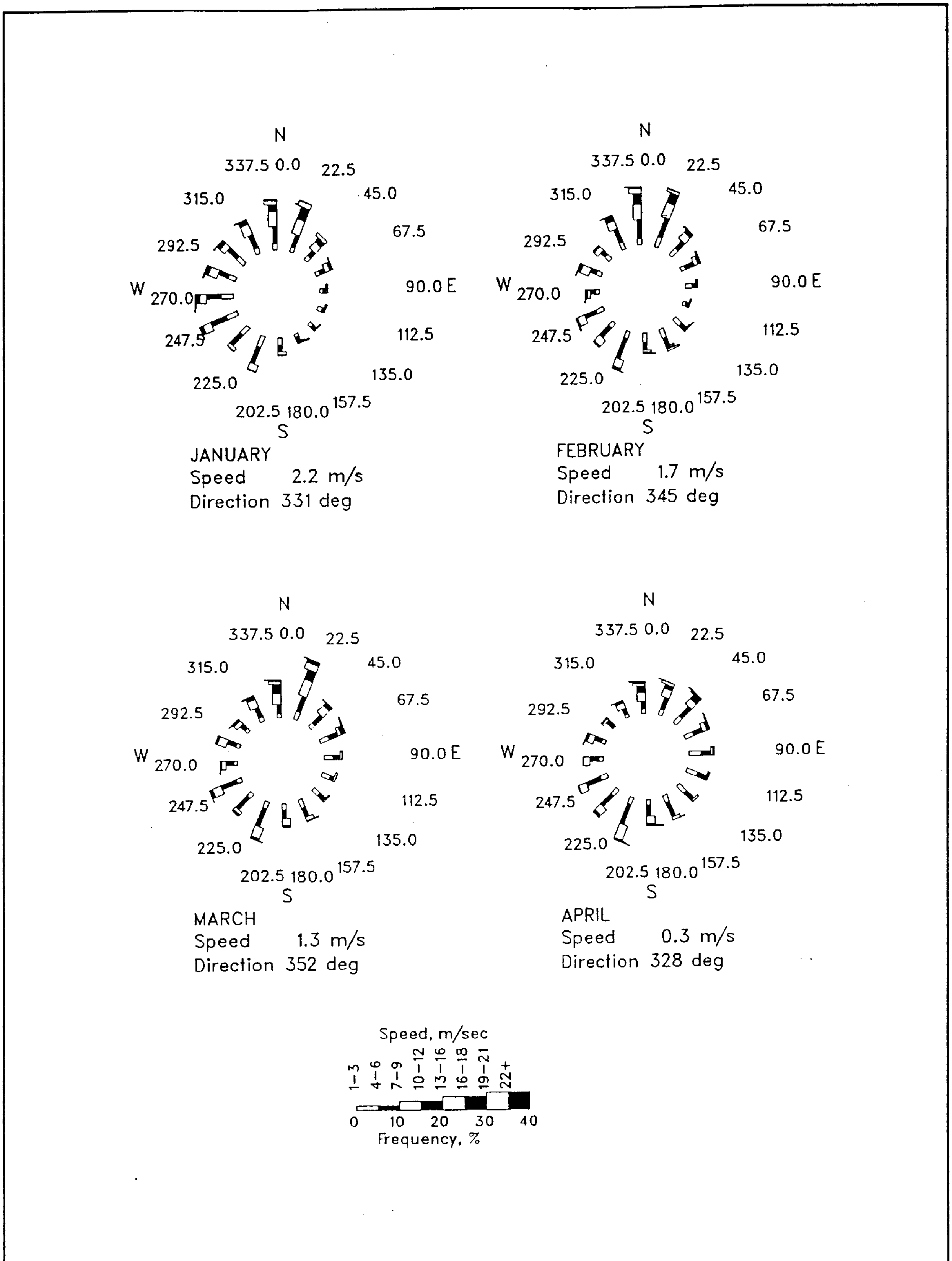

Figure 8. Monthly wind roses for 1980 through 1992 (Continued)

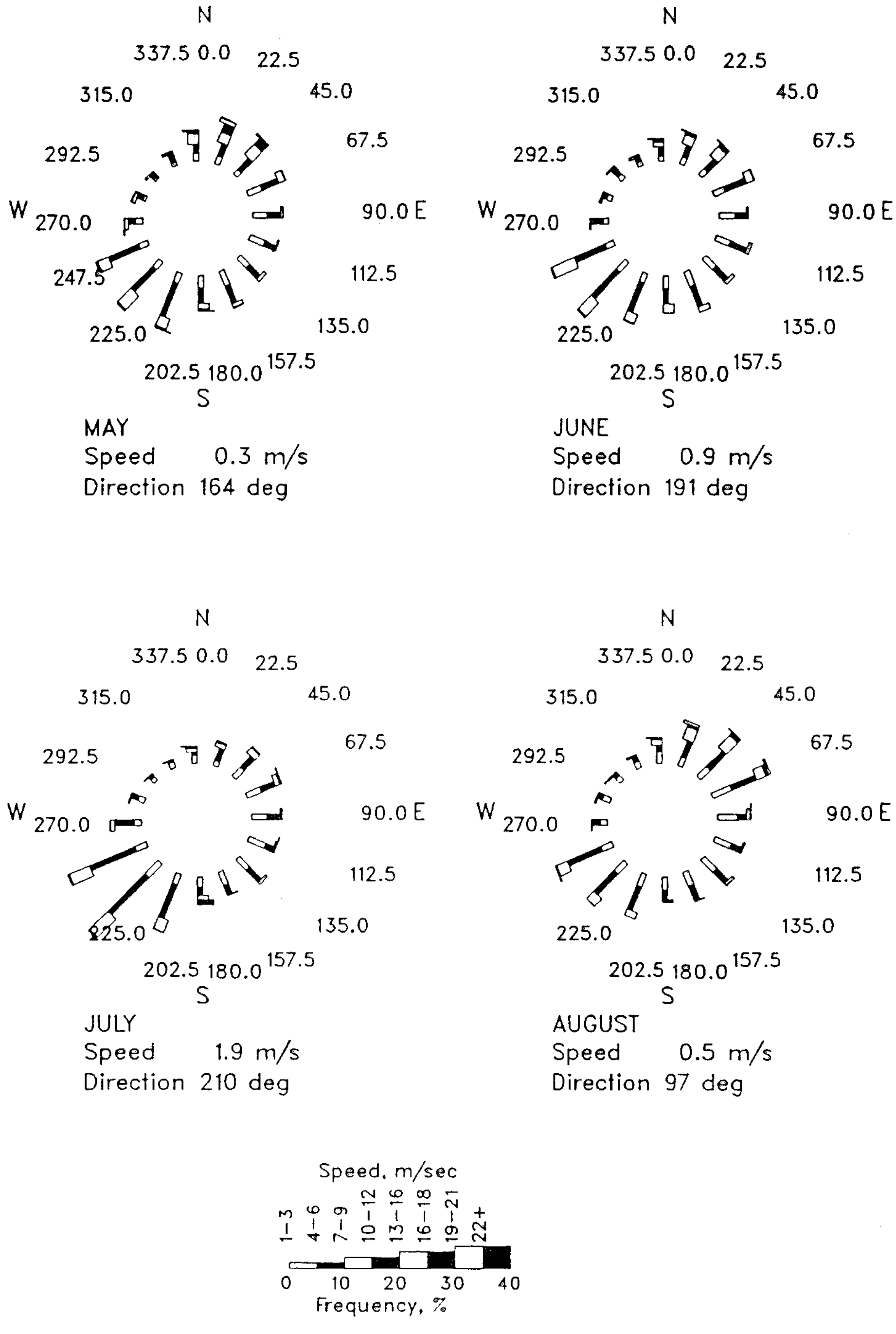

Figure 8. (Continued)

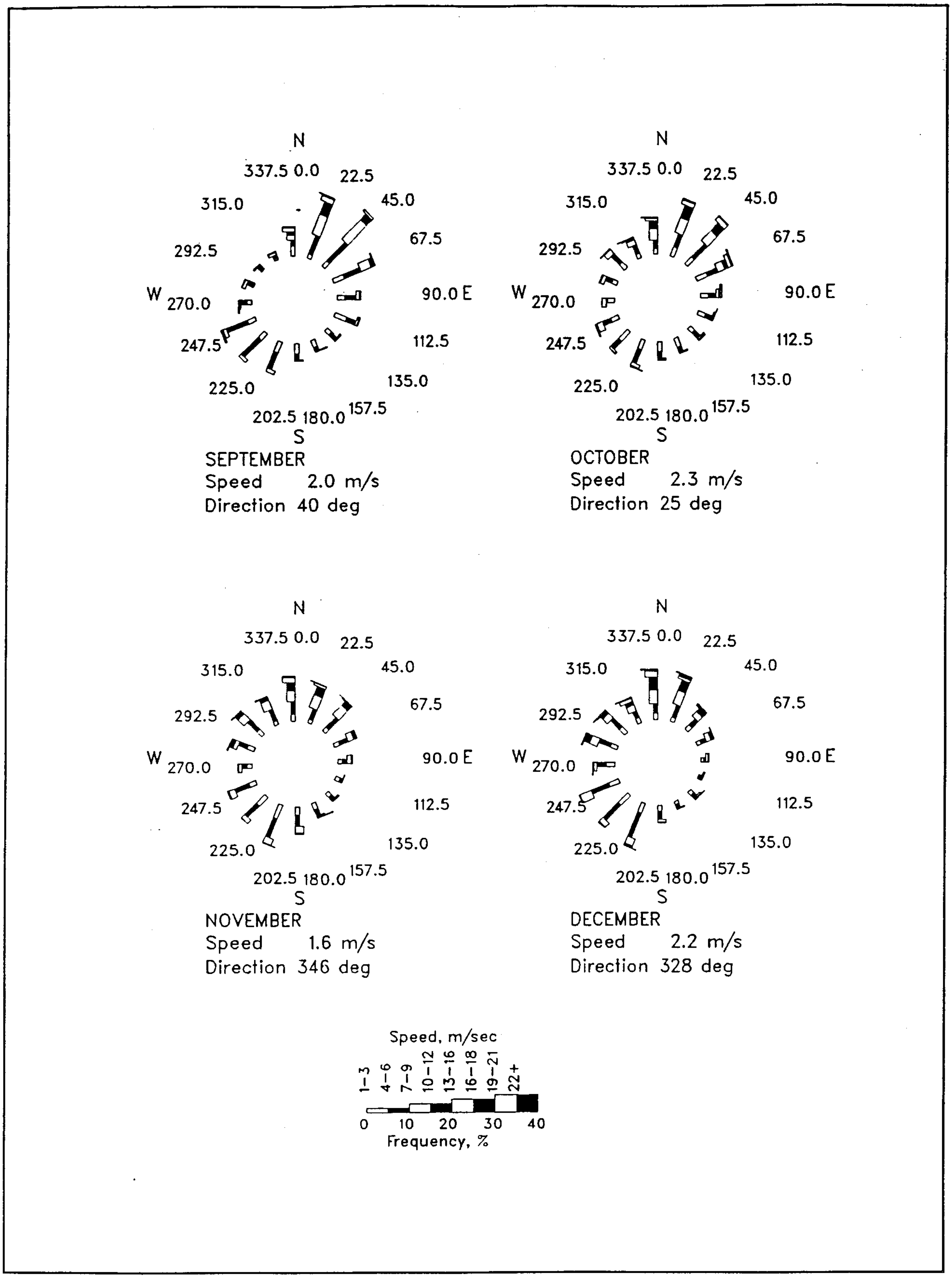

Figure 8. (Concluded)

3 Waves

This chapter presents summaries of the wave data. A discussion of individual major storms is given in Chapter 9 and contains additional wave data for times when wave heights exceeded 2 m at the seaward end of the FRF pier. Appendixes B through E provide more extensive data summaries for each gage, including height and period distributions, wave direction distributions, persistence tables, and spectra during storms.

Wave directions (similar to wind directions) at the FRF are seasonally distributed. Waves approach most frequently from north of the pier in the fall and winter and south of the pier in the summer, with the exception of storm waves that approach twice as frequently from north of the pier. Annually, waves are approximately evenly distributed between north and south (resultant wave direction being almost shore-normal).

Measurement Instruments

The wave gages included two wave staff gages (Gages 645 and 625), one buoy gage (Gage 630), and one pressure gage (Gage 111) as shown in Figure 2. Staff gage 645 failed in May 1992 and was replaced by pressure gage 641 at the same location. The gages were located as follows:

Gage Type/Number	Distance Offshore from Baseline	Water Depth m	Operational Period
Continuous wire (645)	238 m	3.5	11/84-05/92
Pressure Gage (641)	238 m	3.5	11/92-12/92
Continuous wire (625)	567 m	8	11/78-12/92
Accelerometer buoy (630)	6 km	18	11/78-12/92
Pressure gage (111)	1 km	9	09/86-12/92

Staff gages

Two Baylor Company (Houston, TX) parallel cable inductance wave gages (Gage 645 at sta 7+80 and Gage 625 at sta 18+60 (Figure 2)) were mounted on the FRF pier. Rugged and reliable, these gages require little maintenance except to keep tension on the cables and to remove any material that may cause an electrical short between them. They were calibrated prior to installation by creating an electrical short between the two cables at known distances along the cable and recording the voltage output. Electronic signal conditioning amplifiers are used to ensure that the output signals from the

gages are within a 0- to 5-V range. Manufacturer-stated gage accuracy is about 1.0 percent, with a 0.1-percent full-scale resolution; full scale is 14 m for Gage 625 and 8.2 m for Gage 645. These gages are susceptible to lightning damage, but protective measures have been taken to minimize such occurrences. A more complete description of the gages' operational characteristics is given by Grogg (1986). Gage 645 failed in May 1992 and was replaced by a pressure gage (Gage 641) mounted at the same location in November 1992.

Buoy gage

One Datawell Laboratory for Instrumentation (Haarlem, The Netherlands), Waverider buoy gage (Gage 630) measures the vertical acceleration produced by the passage of a wave. The acceleration signal is double-integrated to produce a displacement signal transmitted by radio to an onshore receiver. The manufacturer stated that wave amplitudes are correct to within 3 percent of their actual value for wave frequencies between 0.065 and 0.500 Hz (corresponding to 15 to 2 sec wave periods). The manufacturer also specified that the error gradually increased to 10 percent for wave periods in excess of 20 sec. The results in this report were not corrected for the manufacturer's specified amplitude errors. However, the buoy was calibrated semiannually to ensure that it was within the manufacturer's specification.

Pressure gages

One Senso-Metrics, Incorporated (Simi Valley, CA), pressure transduction gage (Gage 111) installed near the ocean bottom measures the pressure changes produced by the passage of waves creating an output signal that is linear and proportional to pressure when operated within its design limits. Predeployment and postdeployment calibrations are performed at the FRF using a static deadweight tester. The sensor's range is 0 to 25 psi (equivalent to 0 to 17 m of seawater) above atmospheric pressure with a manufacturer-stated accuracy of $\pm$0.25 percent. Copper scouring pads are installed at the sensor's diaphragm to reduce biological fouling, and the system is periodically cleaned by divers.

One Paroscientific, Incorporated (Redmond, WA), pressure transduction gage (Gage 641) installed near ocean bottom on an instrument pile under the pier at station 7+80. Calibration is similar to that performed on Gage 111. The sensor's range is 0 to 45 psia (equivalent to 0 to 30 m of seawater) with a manufacturer-stated accuracy of $\pm$0.01 percent. A perforated copper/nickel plate protects the sensor's diaphragm from biological fouling, and the system is periodically cleaned by divers.

Digital Data Analysis and Summarization

The data were collected, analyzed, and stored on optical disk using the FRF's VAX computer. Data sets were normally collected every 6 hr. During storms, the collection was at 3-hr intervals. For each gage, a data set consisted of four contiguous records of 4,096 points recorded at 0.5 Hz (approximately 34 min long), for a total of 2 hr and 16 min. Analysis was performed on individual 34-min records.

The analysis program computes the first moment (mean) and the second moment about the mean (variance) and then edits the data by checking for "jumps," "spikes," and points exceeding the voltage limit of the gage. A jump is defined as a data value greater than five standard deviations from the previous data value, whereas a spike is a data value more than five standard deviations from the

mean. If less than five consecutive jumps or spikes are found, the program linearly interpolates between acceptable data and replaces the erroneous data values. The editing stops if the program finds more than five consecutive jumps or spikes, or more than a total of 100 bad points, or the variance of the voltage is below 1×10^{-5} squared volts. The statistics and diagnostics from the analysis are saved.

Sea surface energy spectra are computed from the edited time series. Spectral estimates are computed from smaller data segments obtained by dividing the 4,096-point record into several 512-point segments. The estimates are then ensemble-averaged to produce a more accurate spectrum. These data segments are overlapped by 50 percent (known as the Welch (1967) method) which has been shown to produce better statistical properties than nonoverlapped segments. The mean and linear trends are removed from each segment prior to spectral analysis. To reduce side-lobe leakage in the spectral estimates, a data window was applied. The first and last 10 percent of data points were multiplied by a cosine bell (Bingham, Godfrey, and Tukey 1967). Spectra were computed from each segment with a discrete Fast Fourier Transform and then ensemble-averaged. Sea surface spectra from subsurface pressure gages were obtained by applying the linear wave theory transfer function.

Unless otherwise stated, wave height in this report refers to the energy-based parameter H_{mo} defined as four times the zeroth moment wave height of the estimated sea surface spectrum (i.e., four times the square root of the variance) computed from the spectrum passband. Energy computations from the spectra are limited to a passband between 0.05 and 0.50 Hz for surface gages and between 0.05 Hz and a high-frequency cutoff for subsurface gages. This high-frequency limit is imposed to eliminate aliased energy and noise measurements from biasing the computation of H_{mo} and is defined as the frequency where the linear theory transfer function is less than 0.1 (spectral values are multiplied by 100 or more). Smoother and more statistically significant spectral estimates are obtained by band-averaging contiguous spectral components (three components are averaged per band, producing a frequency band width of 0.0117 Hz).

Wave period T_p is defined as the period associated with the maximum energy band in the spectrum, which is computed using a 3-point running average band on the spectrum. The peak period is reported as the reciprocal of the center frequency (i.e., T_p = 1/frequency) of the spectral band with the highest energy. A detailed description of the analysis techniques is presented in Andrews (1987).[2]

Results

The wave conditions for the year are shown in Figure 9. For all four gages, the distributions of wave height for the current year and all years combined are presented in Figures 10 and 11, respectively. Distributions of wave period are presented in Figure 12.

Multiple-year comparisons of data for Gage 111 actually incorporate data for 1985 and 1986 from Gage 640 (a discontinued Waverider buoy previously located at the approximate depth and distance offshore of Gage 111) and data for 1987 from Gage 141, located 30 m south of Gage 111.

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[2] M. E. Andrews. 1987. "Standard wave data analysis procedures for coastal engineering applications," unpublished report prepared for the U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Refraction, bottom friction, and wave breaking contribute to the observed differences in height and period. During the most severe storms when the wave heights exceed 3 m at the seaward end of the pier, the surf zone (wave breaking) has been observed to extend past the end of the pier and occasionally 1 km offshore. This occurrence is a major reason for the differences in the distributions between Gage 630 and the inshore gages. The wave height statistics for the staff gage (Gage 645), located at the landward end of the pier, were considerably lower than those for the other gages. In all but the calmest conditions, this gage is within the breaker zone. Consequently, these statistics represent a lower energy wave climate.

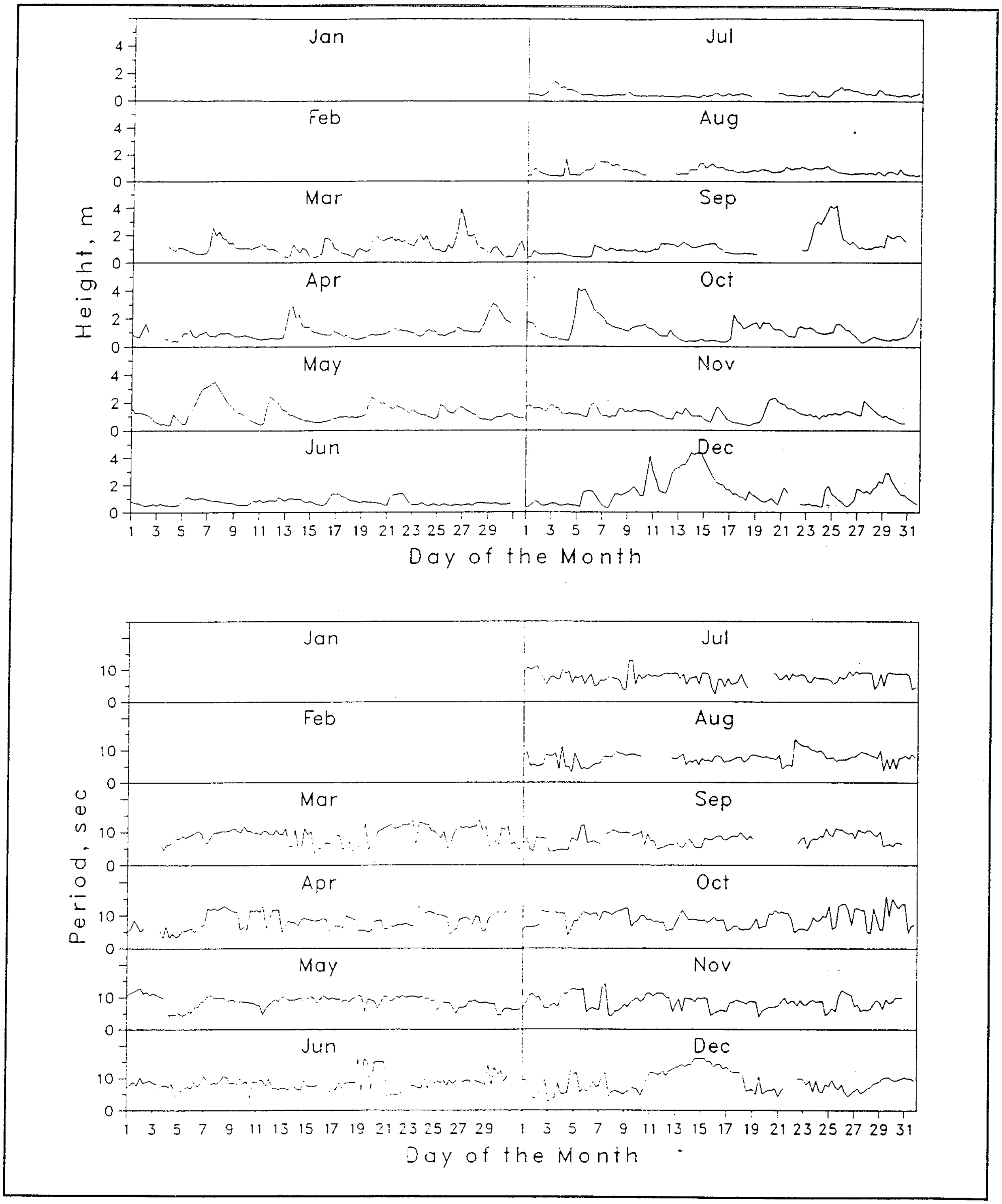


Figure 9. 1992 Time-histories of wave height and period for Gage 630

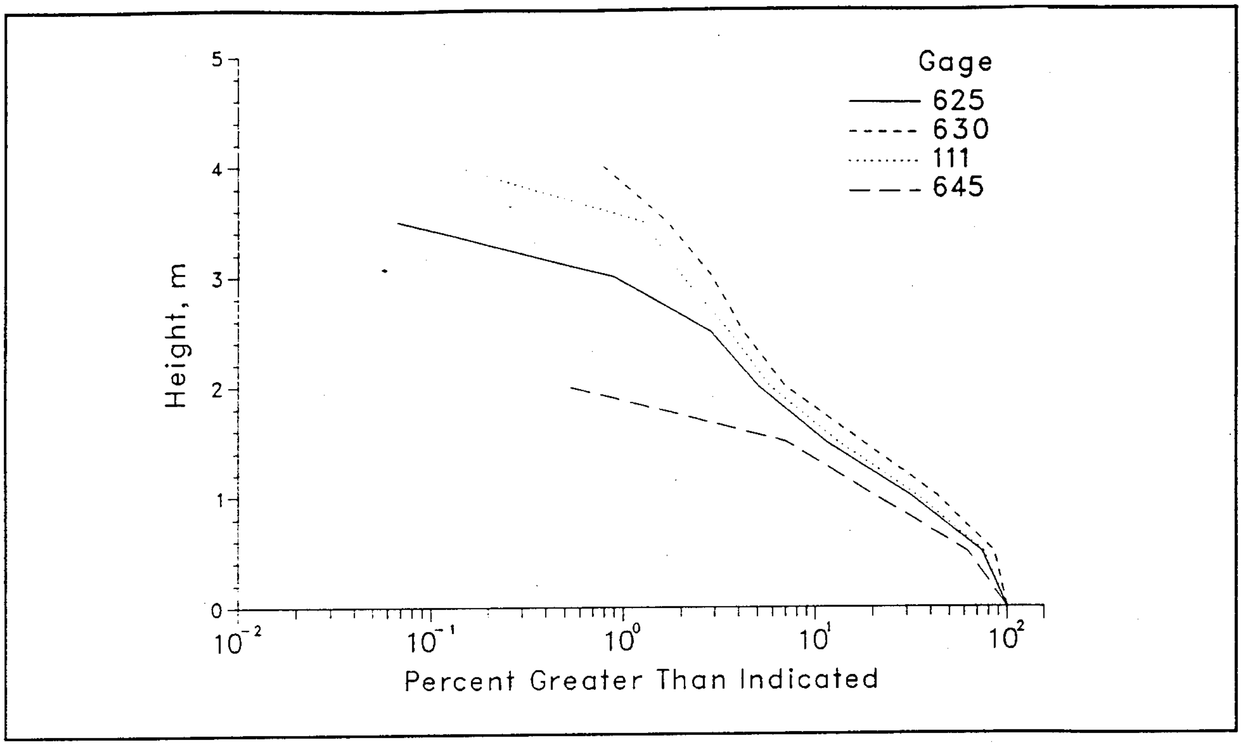


Figure 10. 1992 annual wave height distributions

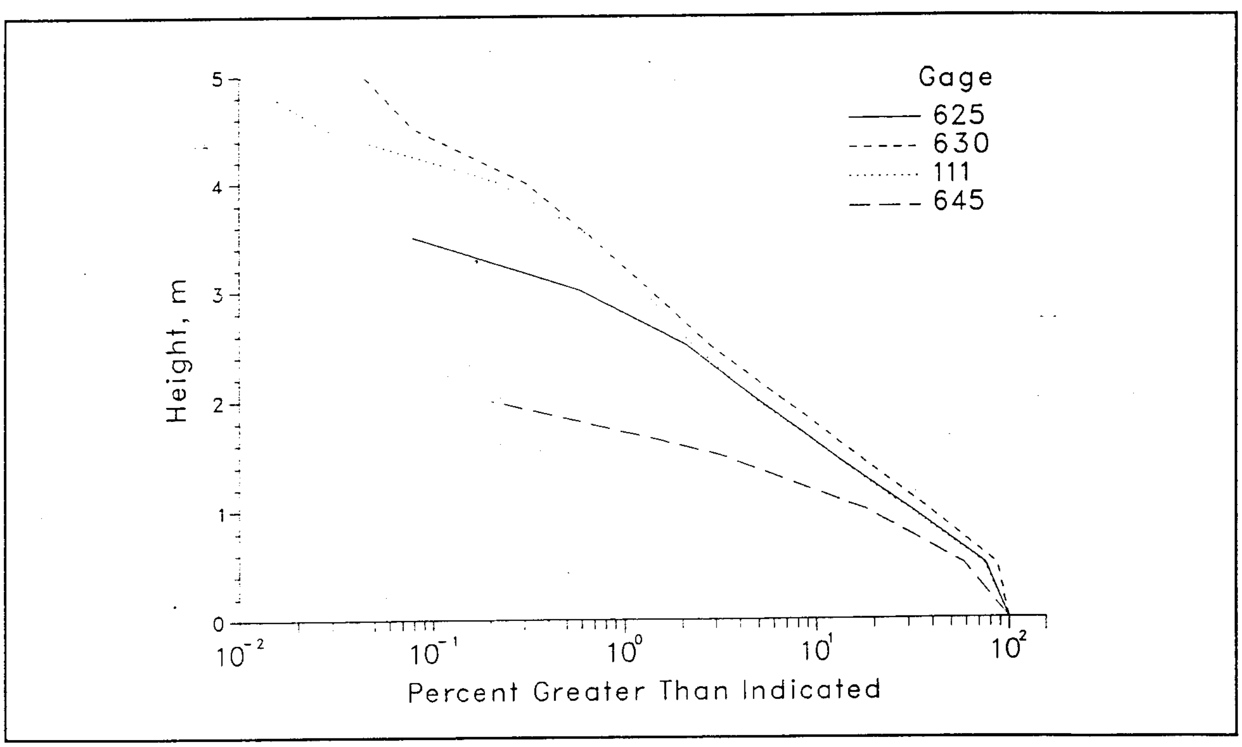


Figure 11. Annual distribution of wave heights for 1980 through 1992

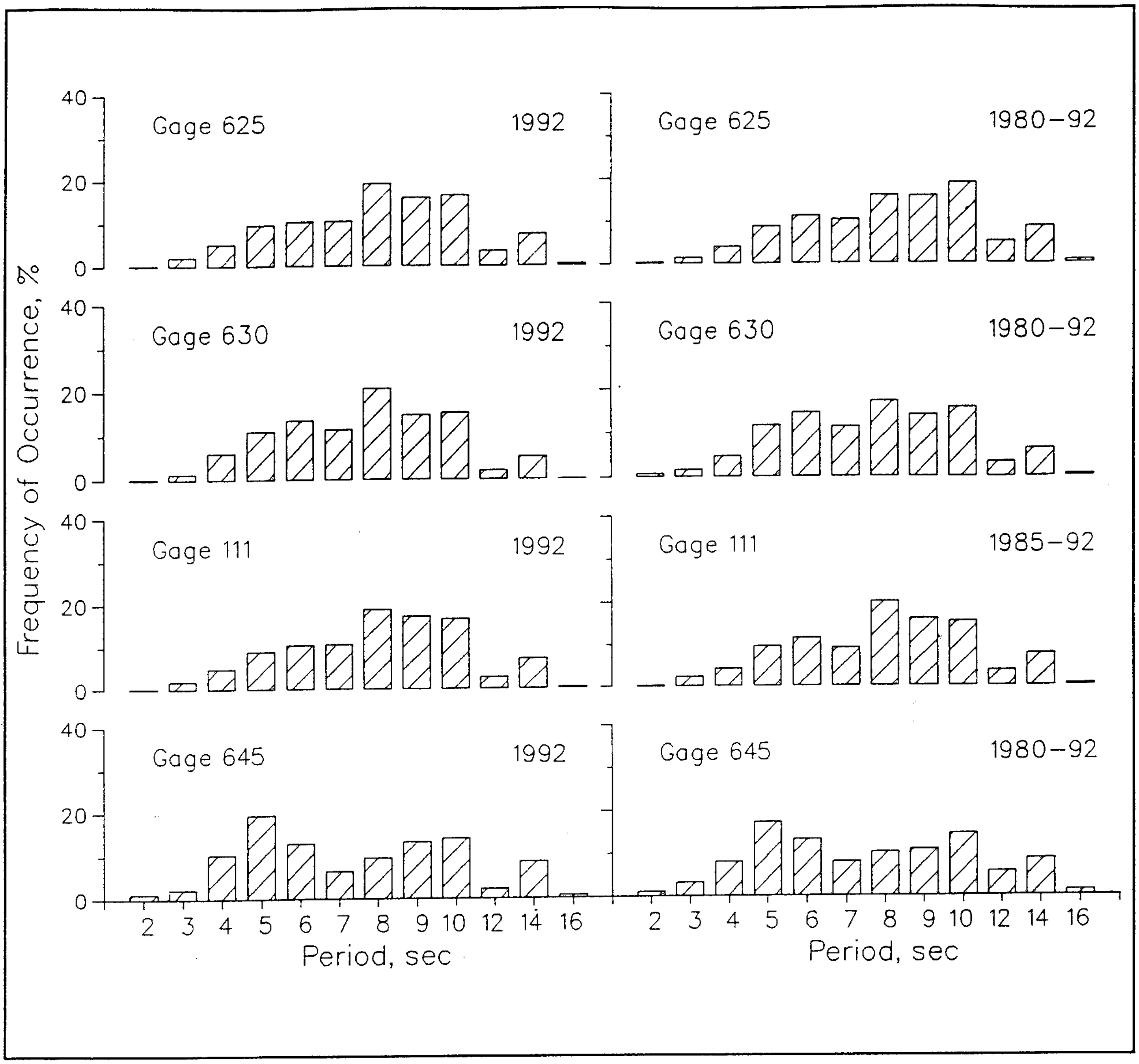


Figure 12. Annual wave period distributions for all gages

Summary wave statistics for the current year and all years combined are presented for Gage 630 in Table 3.

Table 3

Wave Statistics for Gage 630

	1992							1980-1992						
	Height				Period			Height				Period		
Month	Mean m	Std. Dev. m	Extreme m	Date	Mean sec	Std. Dev. sec	Number Obs.	Mean m	Std. Dev. m	Extreme m	Date	Mean sec	Std. Dev. sec	Number Obs.
Jan							0	1.2	0.7	4.5	1983	8.1	2.7	1255
Feb							0	1.2	0.7	5.1	1987	8.4	2.6	1146
Mar	1.2	0.6	3.9	26	8.9	2.5	110	1.2	0.7	4.7	1983	8.7	2.6	1468
Apr	1.1	0.6	3.0	29	8.1	2.6	109	1.0	0.6	5.0	1988	8.5	2.6	1436
May	1.3	0.7	3.5	7	8.6	1.9	114	0.9	0.5	3.5	1992	8.1	2.4	1465
Jun	0.8	0.3	1.4	22	8.5	2.5	115	0.8	0.4	2.7	1991	7.9	2.2	1359
Jul	0.6	0.3	1.5	3	7.5	1.8	114	0.7	0.3	2.1	1985	8.0	2.4	1394
Aug	0.8	0.3	1.6	4	7.5	1.9	111	0.8	0.4	3.6	1981	8.2	2.5	1414
Sep	1.3	0.8	4.2	25	7.8	2.0	107	1.1	0.6	6.1	1985	8.5	2.6	1417
Oct	1.2	0.8	4.2	5	8.9	2.6	120	1.3	0.8	5.4	1991	8.8	2.8	1481
Nov	1.3	0.5	2.3	20	8.4	2.2	120	1.1	0.7	4.6	1991	8.0	2.7	1275
Dec	1.6	1.1	4.4	14	8.8	3.3	120	1.2	0.8	5.6	1980	8.3	3.0	1228
Annual	1.1	0.7	4.4	Dec	8.3	2.4	1140	1.0	0.6	6.1	Sep 1985	8.3	2.6	16338

Annual joint distributions of wave height versus wave period for Gage 630 are presented for 1992 in Table 4, and for all years combined in Table 5. Similar distributions for the other gages are included in Appendixes B-E.

Annual distributions of wave directions (relative to true north) based on daily observations of direction at the seaward end of the pier and height from Gage 625 (or Gage 111 when data for Gage 625 were unavailable) are shown in Figure 13. Monthly wave roses for 1992 and all years combined are presented in Figures 14 and 15, respectively.

Table 4

Annual (1992) Joint Distribution of H_{mo} versus T_p for Gage 630[1]

Height, m	Period, sec 2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-11.9	12.0-13.9	14.0-15.9	16.0-Longer	Total
0.00 - 0.49	9	26	70	88	79	254	474	184	175	.	53	.	1412
0.50 - 0.99	9	88	325	351	430	535	1026	728	500	61	193	.	4246
1.00 - 1.49	.	9	175	395	439	219	342	360	465	35	149	.	2588
1.50 - 1.99	.	.	26	211	307	53	105	96	211	18	35	.	1062
2.00 - 2.49	.	.	.	35	53	44	35	26	53	26	.	.	272
2.50 - 2.99	.	.	.	9	26	26	9	18	26	.	18	.	132
3.00 - 3.49	.	.	.	.	.	.	35	18	35	9	26	.	123
3.50 - 3.99	.	.	.	.	.	.	18	9	26	26	9	.	88
4.00 - 4.49	.	.	.	.	.	.	18	18	9	18	18	.	81
4.50 - 4.99	.	.	.	.	.	.	.	.	.	.	.	.	0
5.00 - Greater	.	.	.	.	.	.	.	.	.	.	.	.	0
Total	18	123	596	1089	1334	1131	2062	1457	1500	193	501	0	

[1] Percent occurrence (x100) of height and period.

Table 5

Annual (1980-1992) Joint Distribution of H_{mo} versus T_p for Gage 630 (All Years)[1]

Height, m	Period, sec 2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-11.9	12.0-13.9	14.0-15.9	16.0-Longer	Total
0.00 - 0.49	27	14	26	60	86	114	332	278	189	66	126	5	1323
0.50 - 0.99	37	136	255	509	592	526	882	744	801	140	229	16	4867
1.00 - 1.49	.	9	143	405	424	251	284	212	322	40	121	3	2214
1.50 - 1.99	.	.	13	164	245	111	83	78	126	32	72	4	928
2.00 - 2.49	.	.	1	24	95	67	54	37	59	27	36	1	401
2.50 - 2.99	.	.	.	1	12	32	18	13	32	10	24	1	143
3.00 - 3.49	.	.	.	.	1	12	12	12	14	5	8	1	65
3.50 - 3.99	.	.	.	.	.	1	6	7	11	4	5	.	34
4.00 - 4.49	.	.	.	.	.	.	2	4	7	1	3	1	18
4.50 - 4.99	.	.	.	.	.	.	.	1	2	.	.	1	4
5.00 - Greater	.	.	.	.	.	.	1	.	1	1	1	1	5
Total	64	159	438	1163	1455	1114	1674	1386	1564	326	625	34	

[1] Percent occurrence (x100) of height and period.

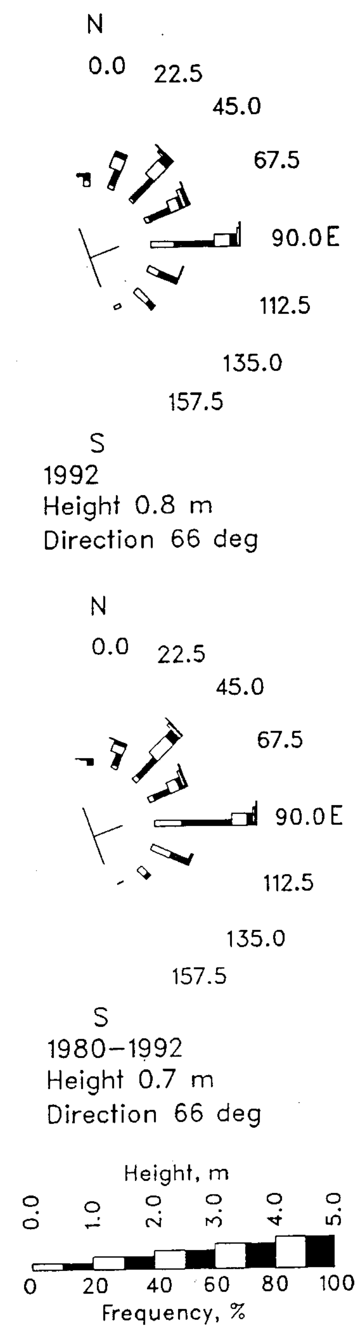


Figure 13. Annual wave roses

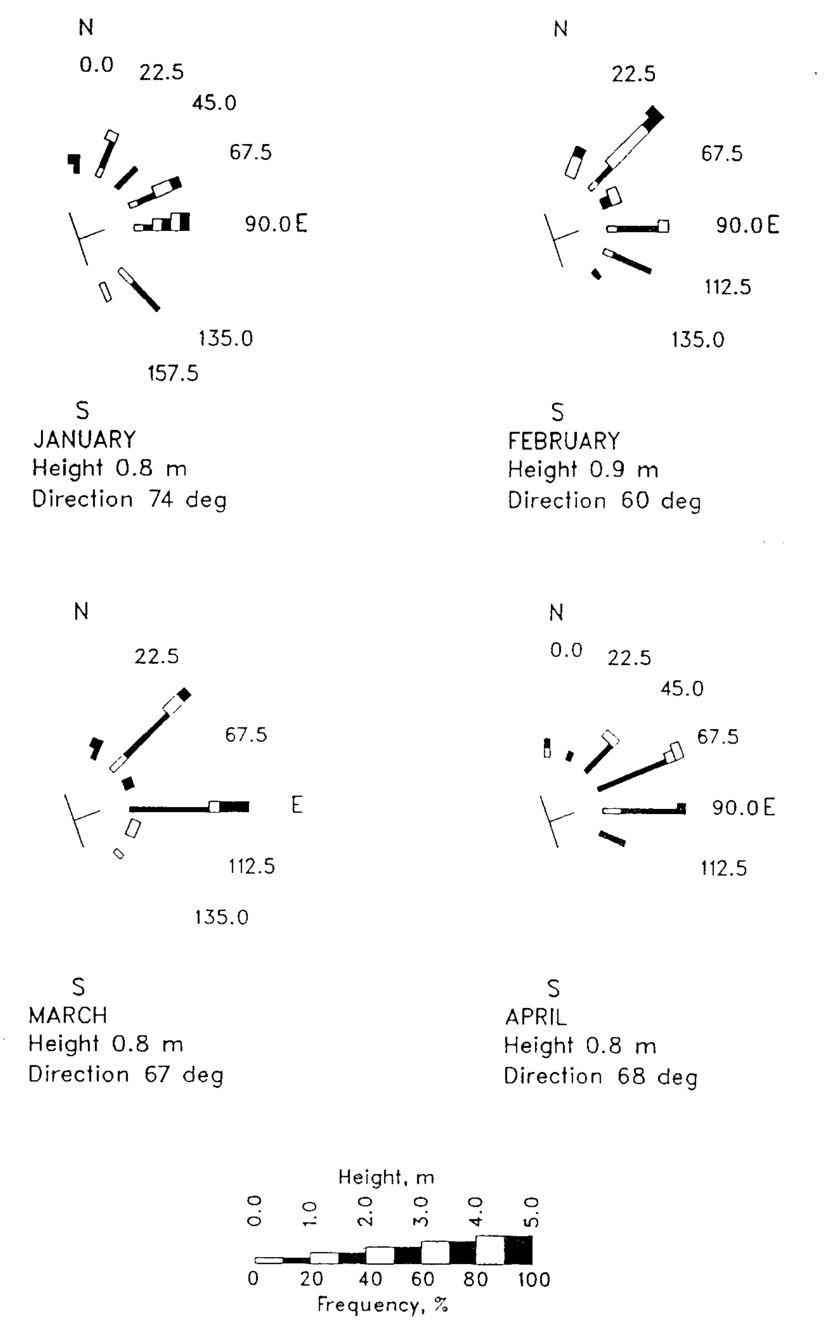


Figure 14. Monthly wave roses for 1992 (Continued)

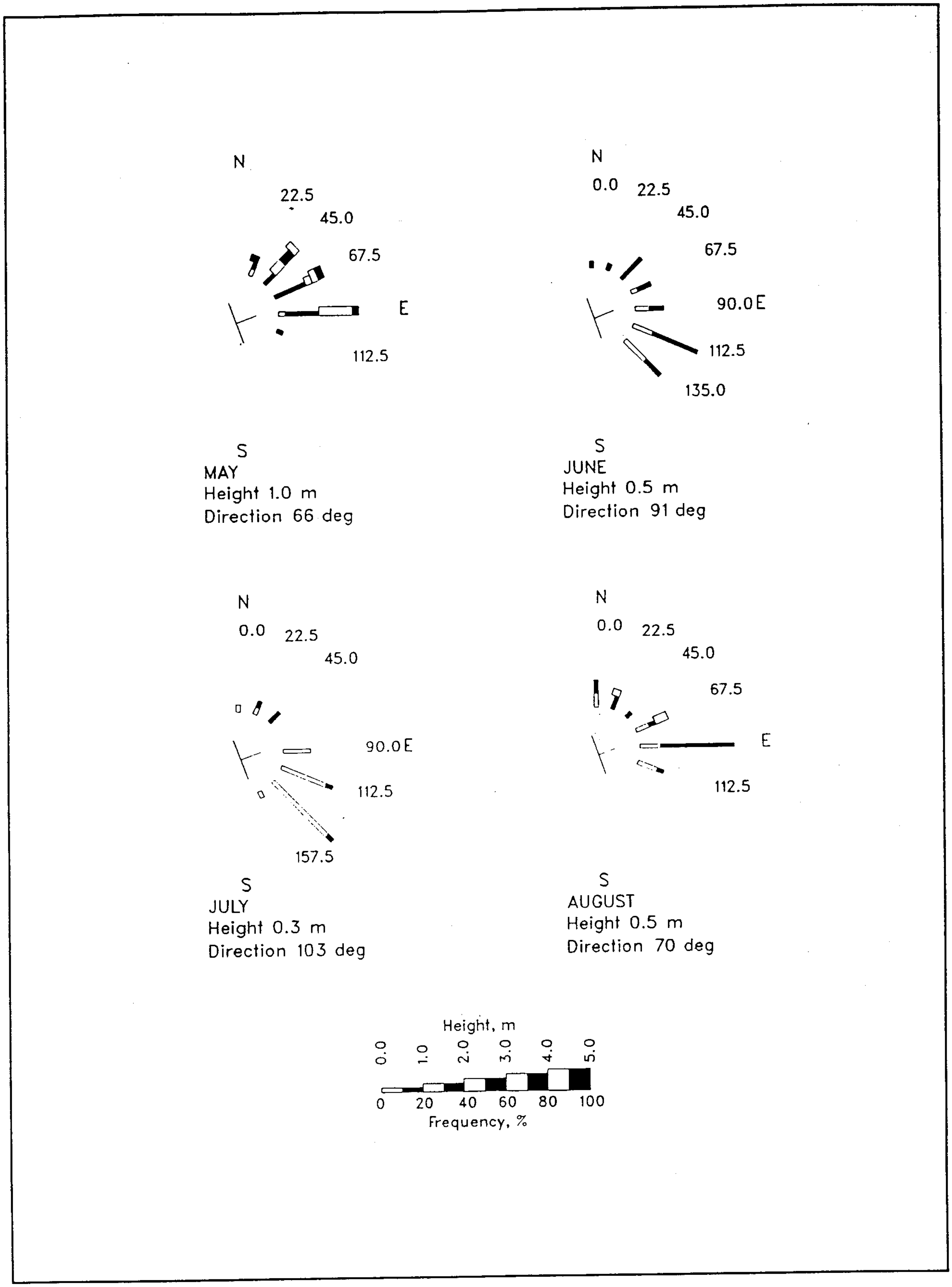


Figure 14. (Continued)

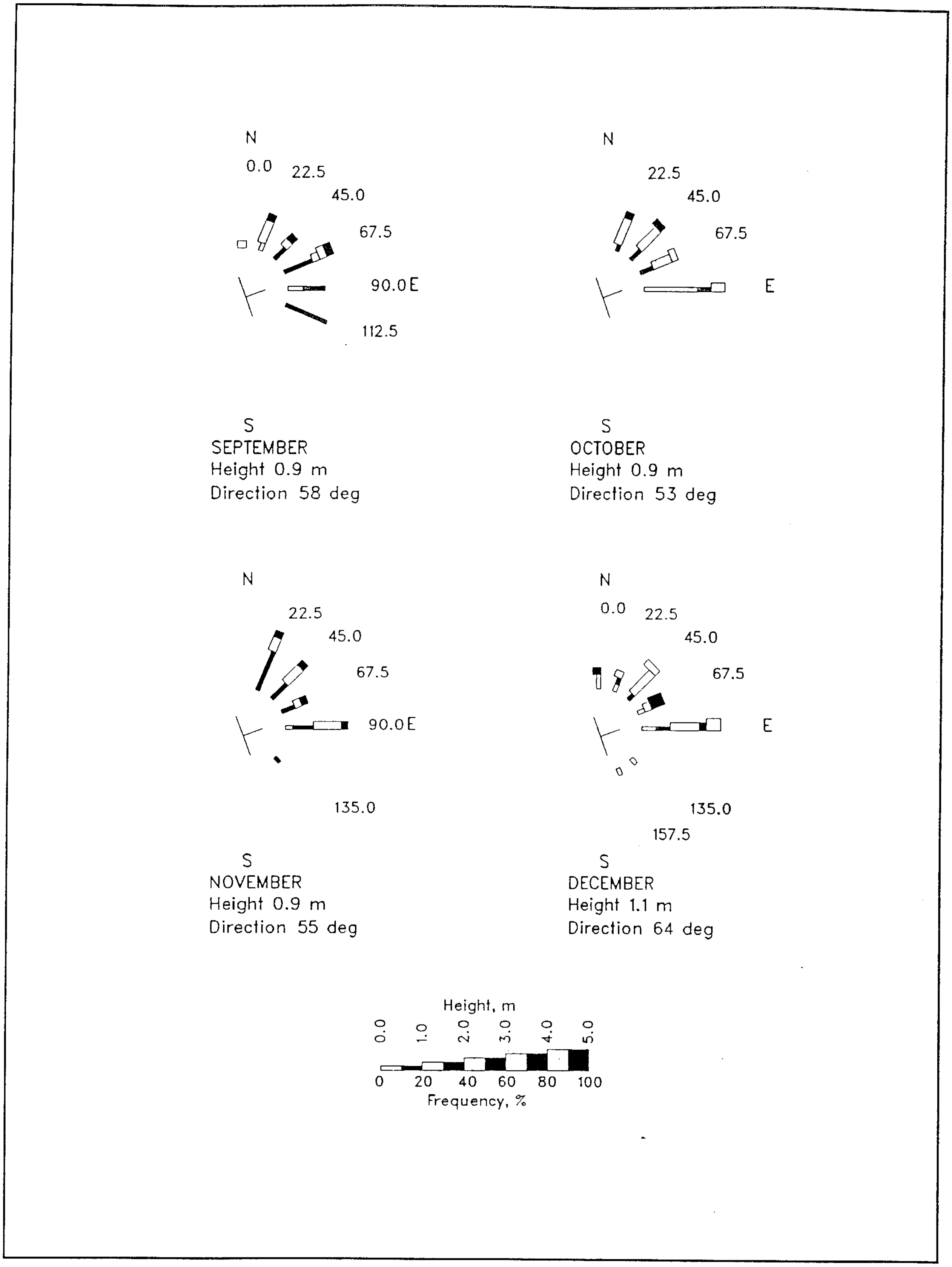


Figure 14. (Concluded)

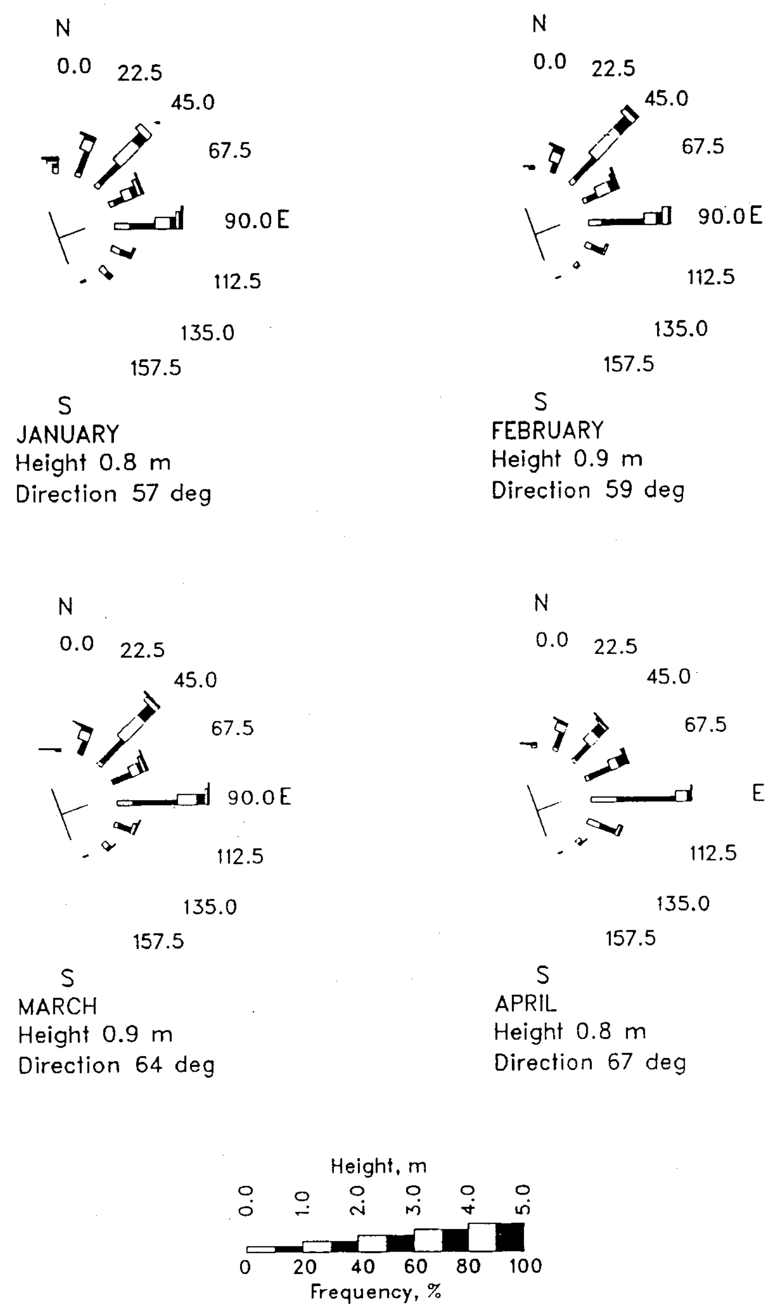


Figure 15. Monthly wave roses for 1980 through 1992 (Continued)

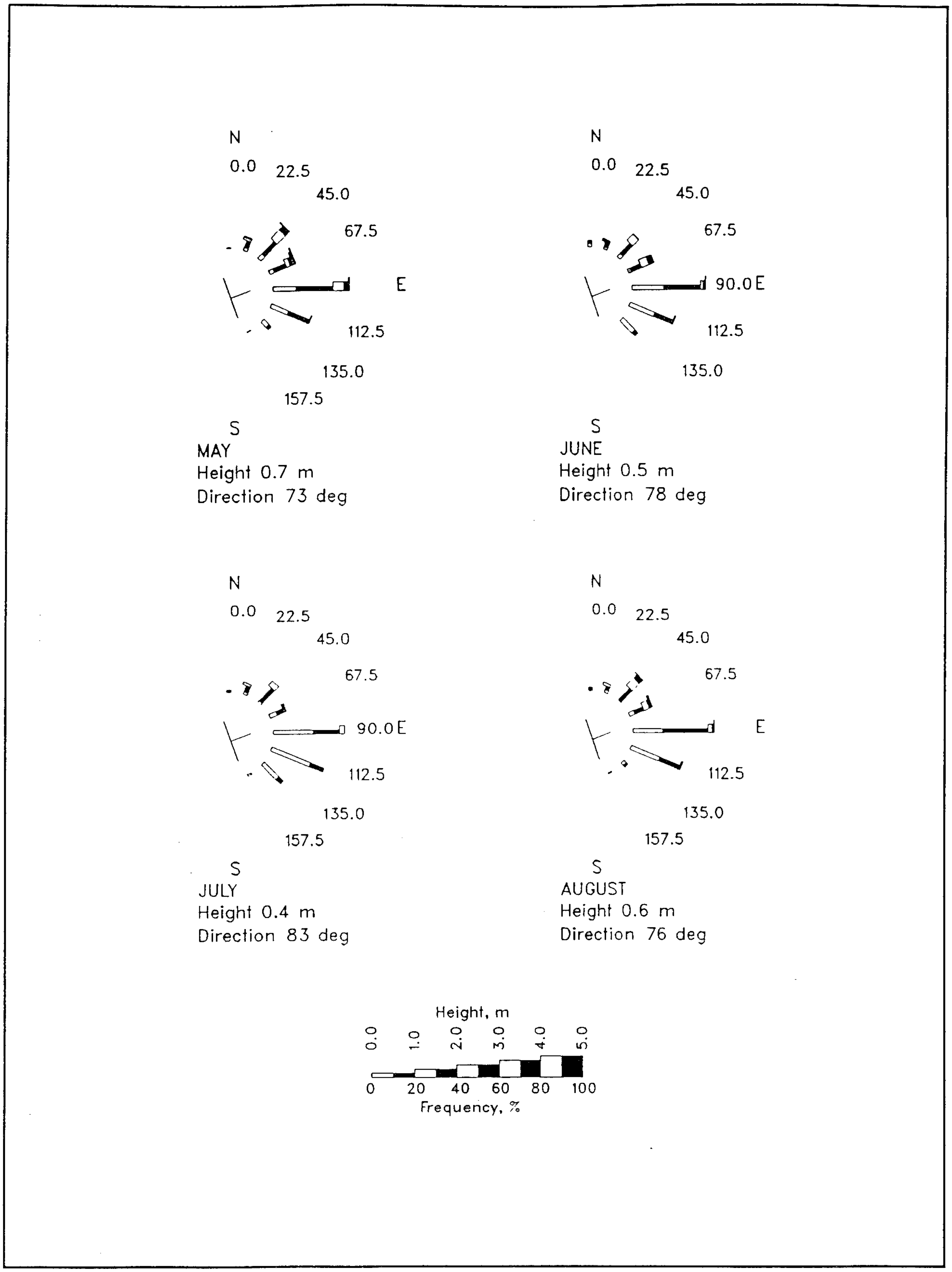


Figure 15. (Continued)

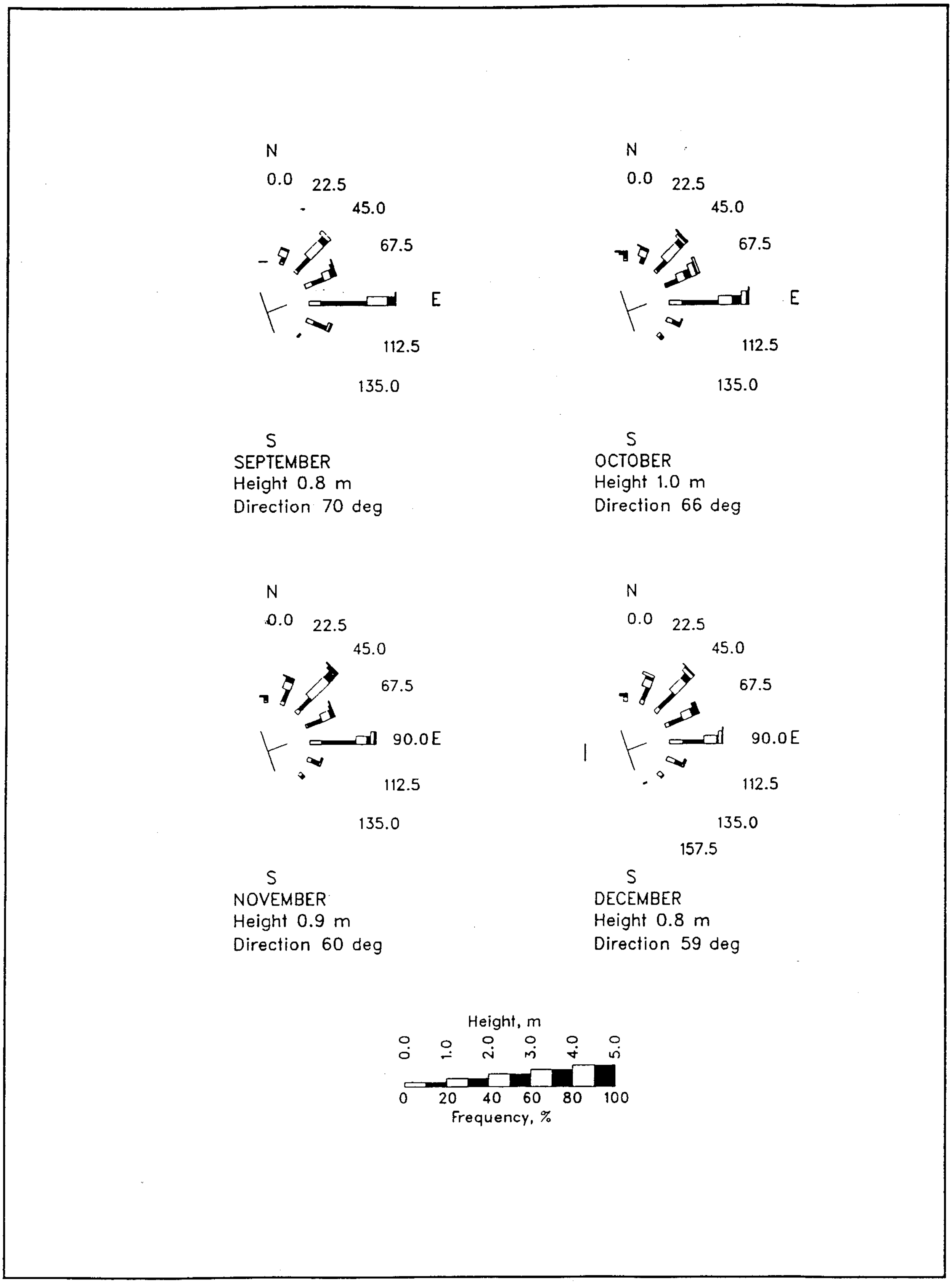


Figure 15. (Concluded)

4 Currents

Surface current speed and direction at the FRF are influenced by winds, waves, and, indirectly, by the bottom topography. The extent of the respective influences varies daily. However, winds tend to dominate the currents at the seaward end of the pier, whereas waves dominate within the surf zone.

Observations

Near 0700 EST, daily observations of surface current speed and direction were made at (a) the seaward end of the pier, (b) the midsurf position on the pier, and (c) 10 to 15 m from the beach 500 m updrift of the pier. Surface currents were determined by observing the movement of dye on the water surface.

Results

Annual mean and mean currents for 1980 through 1992 are presented in Table 6 and in Figure 16. Figure 16 shows the daily and average annual measurements at the beach, pier midsurf, and pier end locations. Since the relative influences of the winds and waves vary with position from shore, the current speeds and, to some extent, direction vary at the beach, midsurf, and pier end locations. Magnitudes generally are largest at the midsurf location and lowest at the end of the pier.

Table 6

Mean Longshore Surface Currents[1]

Month	Pier End, cm/sec 1992	Pier End, cm/sec 1980-1992	Pier Midsurf, cm/sec 1992	Pier Midsurf, cm/sec 1980-1992	Beach, cm/sec 1992	Beach, cm/sec 1980-1992
Jan	14	20	11	16	6	6
Feb	21	11	33	15	14	10
Mar	8	12	10	9	8	8
Apr	18	15	-8	5	-4	0
May	21	20	11	7	2	3
Jun	8	10	-37	-11	-19	-3
Jul	-3	1	-17	-10	-11	-9
Aug	5	11	-13	-6	-7	-4
Sep	19	11	5	3	5	0
Oct	14	5	25	6	17	3
Nov	11	7	8	5	-5	1
Dec	11	12	6	11	-6	1
Annual	12	11	3	4	0	1

1 + = southward; - = northward.

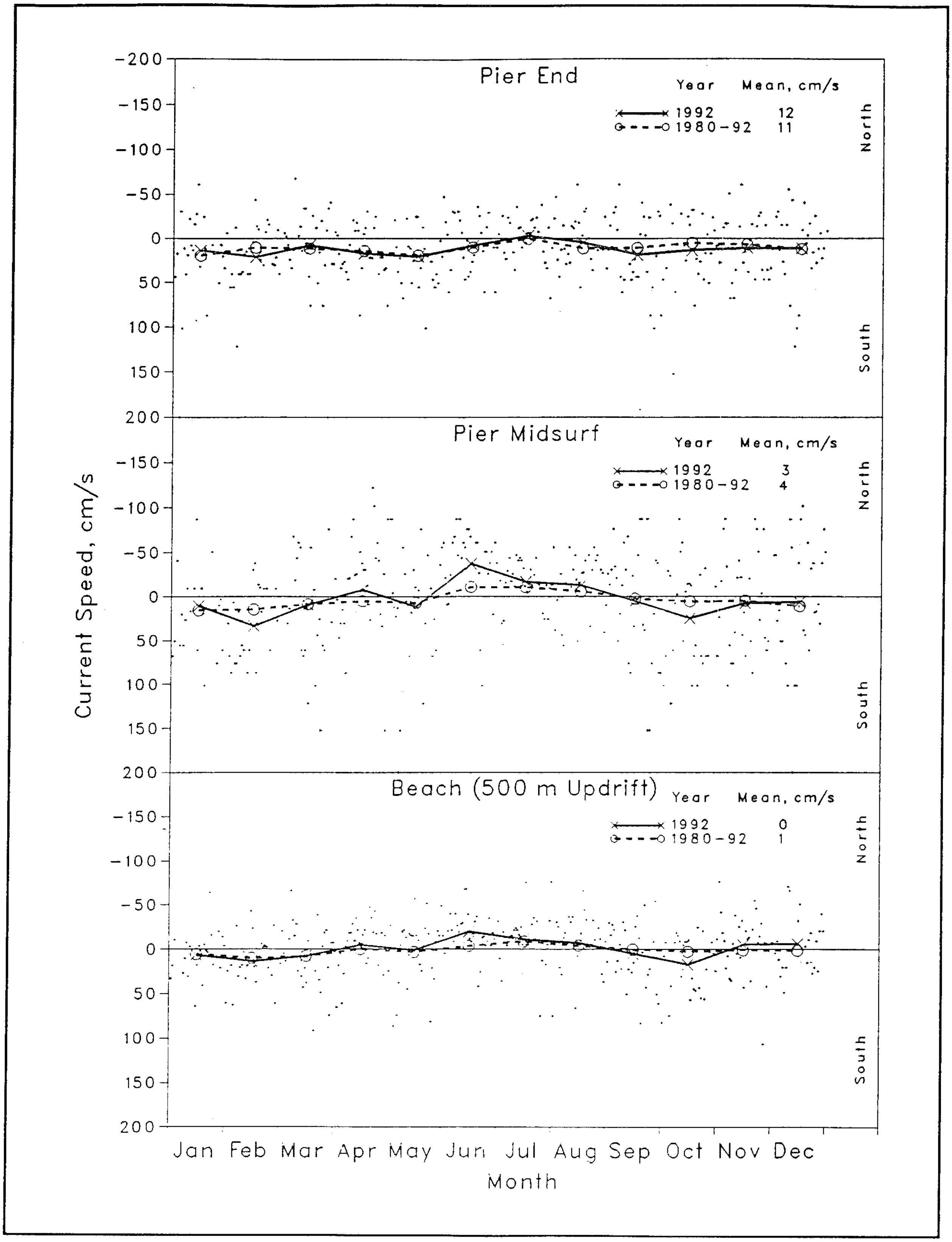


Figure 16. Daily current speeds and directions with monthly means for 1992

5 Tides and Water Levels

Measurement Instrument

Water level data were obtained from an NOAA/NOS control tide station (sta 865-1370) located at the seaward end of the research pier (Figure Figure 2) by using a Leupold and Stevens, Inc. (Beaverton, OR), digital tide gage. This analog-to-digital recorder is a float-activated, negator-spring, counterpoised instrument that mechanically converts the vertical motion of a float into a coded, punched paper tape record. The below-deck installation at pier sta 19+60 consisted of a 30.5-cm-diam stilling well with a 2.5-cm orifice and a 21.6-cm-diam float.

Operation and tending of the tide gage conformed to NOS standards. The gage was checked daily for proper operation of the punch mechanism and for accuracy of the time and water level information. The accuracy was determined by comparing the gage level reading with a level read from a reference electric tape gage. Once a week, a heavy metal rod was lowered down the stilling well and through the orifice to ensure free flow of water into the well. During the summer months, when biological growth was most severe, divers inspected and cleaned the orifice opening as required.

The tide station was inspected quarterly by an NOAA/NOS tide field group. Tide gage elevation was checked using existing NOS control positions, and the equipment was checked and adjusted as needed. Both NOS and FRF personnel also reviewed procedures for tending the gage and handling the data. Any specific comments on the previous months of data were discussed to ensure data accuracy.

Digital paper tape records of tide heights taken every 6 min were analyzed by the Tides Analysis Branch of NOS. An interpreter created a digital magnetic computer tape from the punch paper tape, which was then processed on a large computer. First, a listing of the instantaneous tidal height values was created for visual inspection. If errors were encountered, a computer program was used to fill in or recreate bad or missing data using correct values from the nearest NOS tide station and accounting for known time lags and elevation anomalies. The data were plotted, and a new listing was generated and rechecked. When the validity of the data had been confirmed, monthly tabulations of daily highs and lows, hourly heights (instantaneous height selected on the hour), and various extreme and/or mean water level statistics were computed.

Results

Tides at the FRF are semidiurnal with both daily high and low tides approximately equal. Tide height statistics are presented in Table 7. Figure 17 plots the monthly tide statistics for all available

data, and Figure 18 compares the distribution of daily high and low water levels and hourly tide heights. The monthly or annual mean sea level (MSL) reported is the average of the hourly heights, whereas the mean tide level is midway between mean high water (MHW) and mean low water (MLW), which are the averages of the daily high- and low-water levels, respectively, relative to NGVD. Mean range (MR) is the difference between MHW and MLW levels, and the lowest water level for the month is the extreme low (EL) water, while the highest water level is the extreme high (EH) water level.

Table 7

Tide Height Statistics[1]

Month or Year	Mean High Water	Mean Tide Level	Mean Sea Level	Mean Low Water	Mean Range	Extreme High	Date	Extreme Low	Date
					1992				
Jan	51	11	11	-29	88	104	4	-77	17
Feb	55	15	15	-25	80	87	7	-58	21
Mar	49	8	8	-33	82	94	19	-67	18
Apr	53	12	12	-28	81	81	29	-63	18
May	58	18	18	-23	81	101	6	-60	3
Jun	56	17	17	-23	79	83	5	-38	9
Jul	54	12	12	-30	84	96	2	-53	31
Aug	56	14	14	-28	84	79	27	-61	1
Sep	59	18	18	-24	83	120	25	-46	1
Oct	57	17	17	-26	83	88	26	-61	24
Nov	55	15	15	-26	81	89	25	-60	23
Dec	51	10	10	-31	82	125	12	-59	26
1992	55	14	14	-27	82	125	Dec	-77	Jan
					Prior Years				
1991	55	15	15	-26	81	125	Oct	-83	Dec
1990	49	9	9	-32	81	109	May	-78	Feb
1989	49	9	9	-31	80	199	Mar	-77	Apr
1988	46	6	7	-33	79	129	Apr	-72	Dec
1987	55	15	16	-24	79	113	Jan	-63	Nov
1986	60	13	13	-35	95	123	Dec	-108	Jan
1985	59	10	11	-37	96	136	Dec	-93	Apr
1984	64	16	16	-32	97	147	Oct	-77	Jul
1983	68	19	19	-30	98	143	Jan	-73	Mar
1982	58	8	9	-42	99	127	Oct	-108	Feb
1981	59	8	9	-42	101	149	Nov	-110	Apr
1980	59	8	8	-43	102	118	Mar	-119	Mar
1979	60	9	9	-43	103	121	Feb	-95	Sep
1979-1991	57	11	11	-35	92	199	Mar 1989	-119	Mar 1980

1 Measurements are in centimeters.

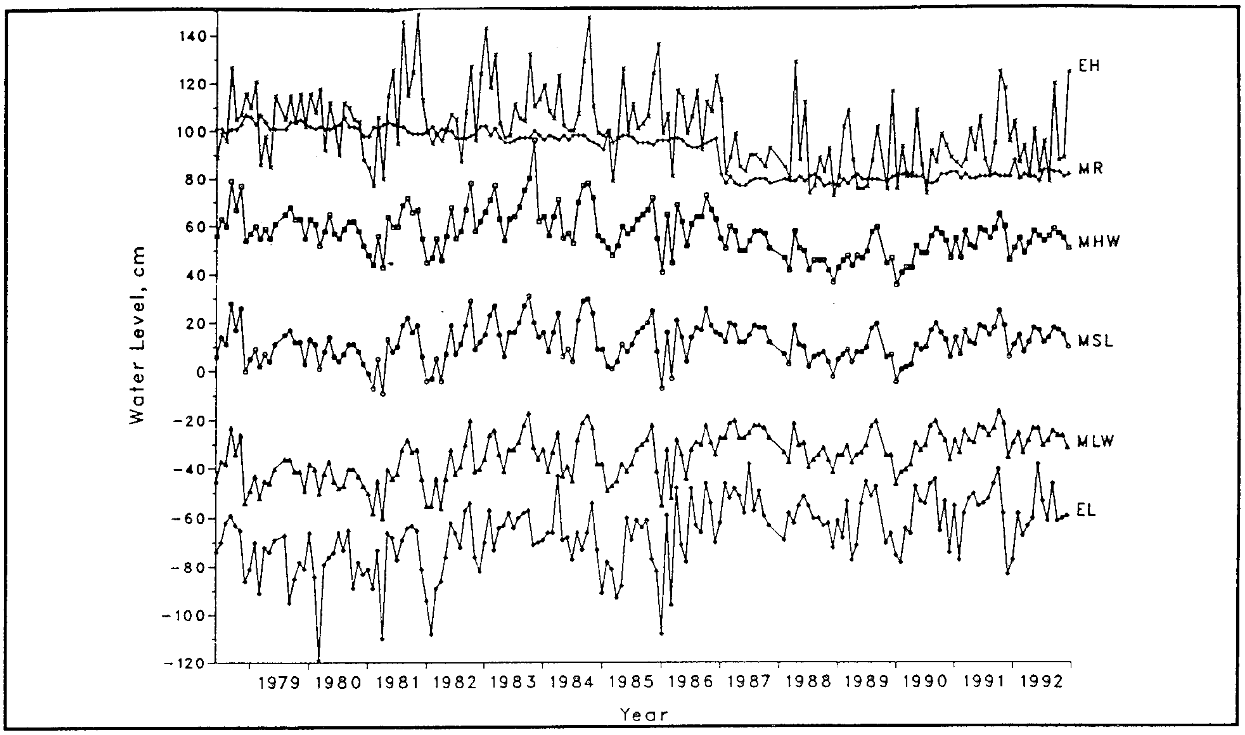


Figure 17. Monthly tide and water level statistics relative to NGVD

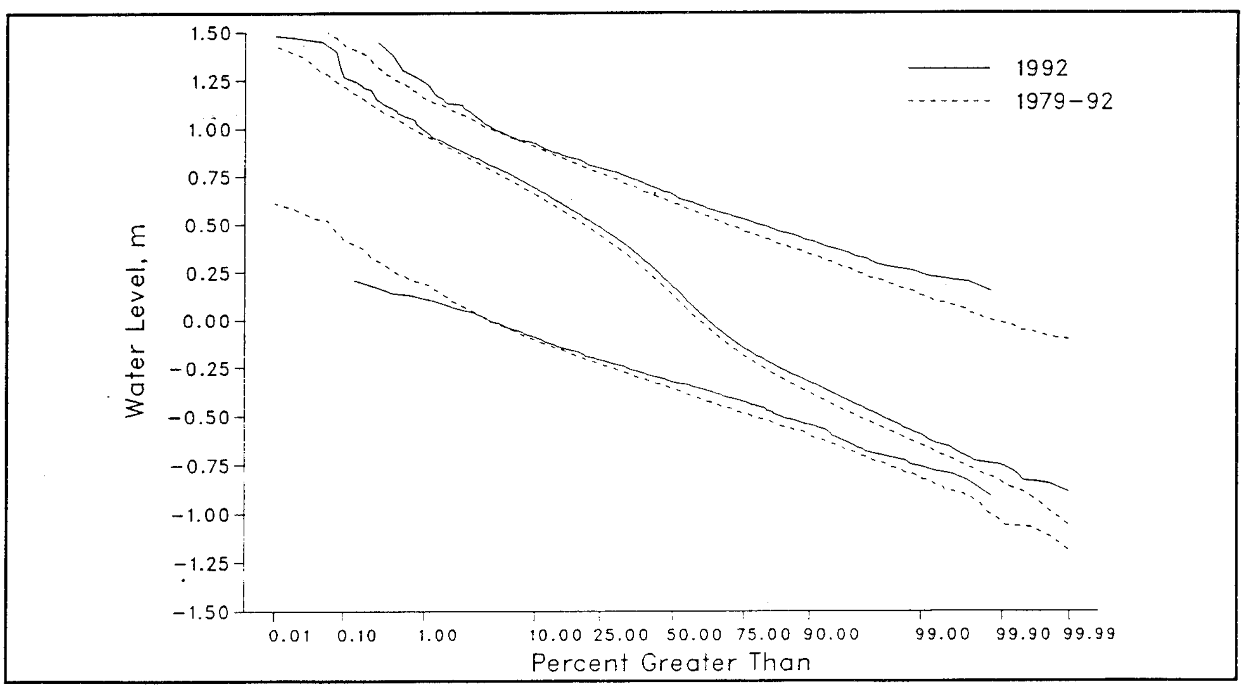


Figure 18. Distributions of hourly tide heights and high- and low-water levels

6 Water Characteristics

Monthly averages of daily measurements of surface water temperature, visibility, and density at the seaward end of the FRF pier are given in Table 8. The summaries represent single observations made near 0700 EST and, therefore, may not reflect daily average conditions since such characteristics can change within a 24-hr period. Large temperature variations were common when there were large differences between the air and water temperatures and variations in wind direction. From past experience, persistent onshore winds move warmer surface water toward the shoreline, although offshore winds cause colder bottom water to circulate shoreward, resulting in lower temperatures.

Table 8

Mean Surface Water Characteristics

	Temperature deg C		Visibility m		Density g/cm^3	
Month	1992	1980-1992	1992	1980-1992	1992	1980-1992
Jan	8.3	6.4	1.1	1.3	1.0246	1.0235
Feb	6.8	5.7	2.2	1.8	-	1.0232
Mar	8.2	7.2	1.9	1.6	1.0243	1.0229
Apr	10.9	11.1	2.1	2.0	1.0235	1.0225
May	15.0	15.4	1.1	2.3	1.0211	1.0220
Jun	18.8	19.6	2.3	3.3	1.0209	1.0213
Jul	19.1	21.9	3.5	3.8	1.0227	1.0215
Aug	22.9	23.8	3.7	3.2	1.0211	1.0204
Sep	23.2	23.1	2.3	2.3	1.0209	1.0209
Oct	17.8	19.4	1.1	1.5	1.0223	1.0217
Nov	14.4	14.8	1.3	1.1	1.0229	1.0229
Dec	9.1	10.0	1.1	1.1	1.0233	1.0235
Annual	14.6	14.9	2.0	2.1	1.0225	1.0222

Temperature

Daily sea surface water temperatures (Figure 19) were measured with an NOS water sampler and thermometer. Monthly mean water temperatures (Table 8) varied with the air temperatures (see Table 2).

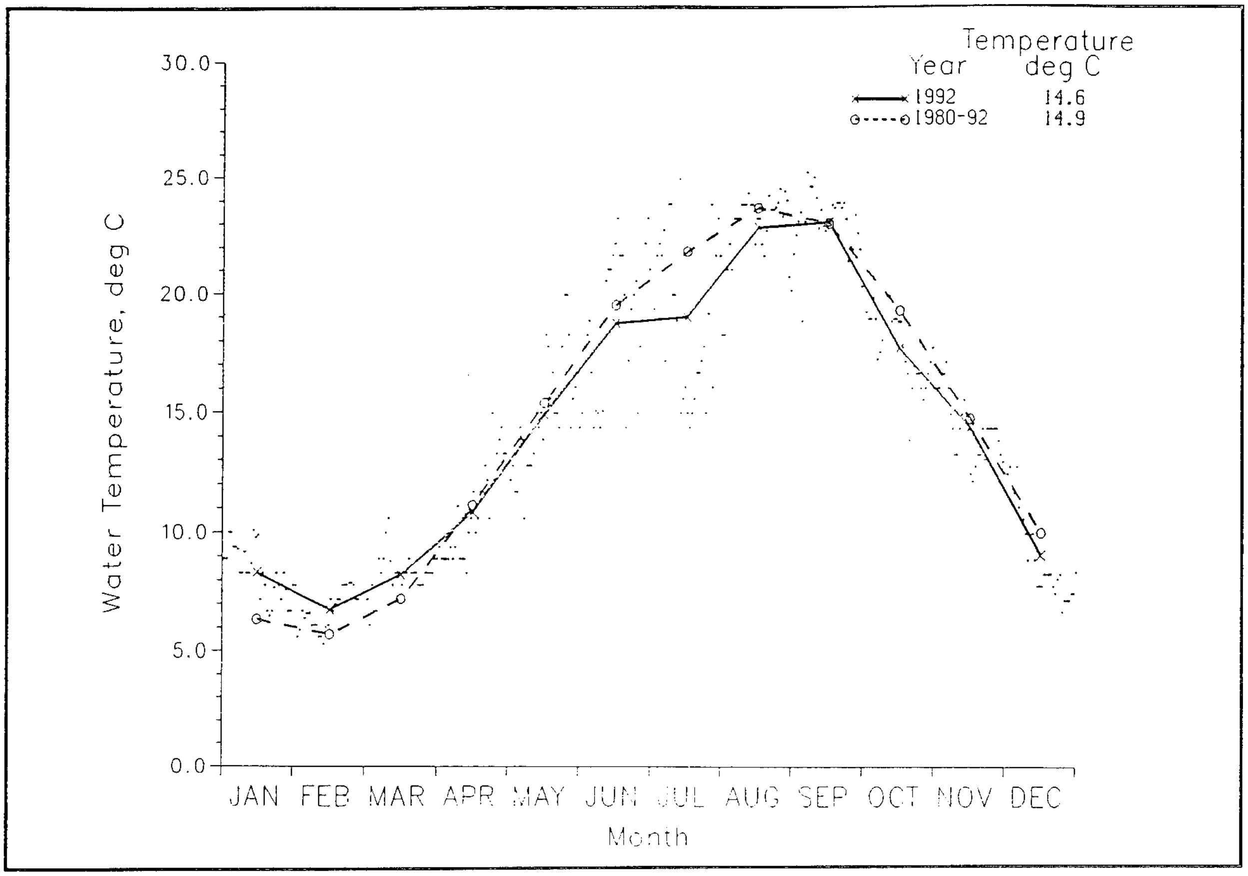


Figure 19. Daily water temperature values with monthly means

Visibility

Visibility in coastal nearshore waters depends on the amount of salts, soluble organic material, detritus, living organisms, and inorganic particles in the water. These dissolved and suspended materials change the absorption and attenuation characteristics of the water that vary daily and yearly.

Visibility was measured with a 0.3-m-diam Secchi disk, and similar to water temperature, variation was related to onshore and offshore winds. Onshore winds moved warm clear surface water toward shore, whereas offshore winds brought up colder bottom water with large concentrations of suspended matter. Figure 20 presents the daily and monthly mean surface visibility values for the year. Large variations were common, and visibility less than 1 m was expected in any month. Monthly means are given in Table 8.

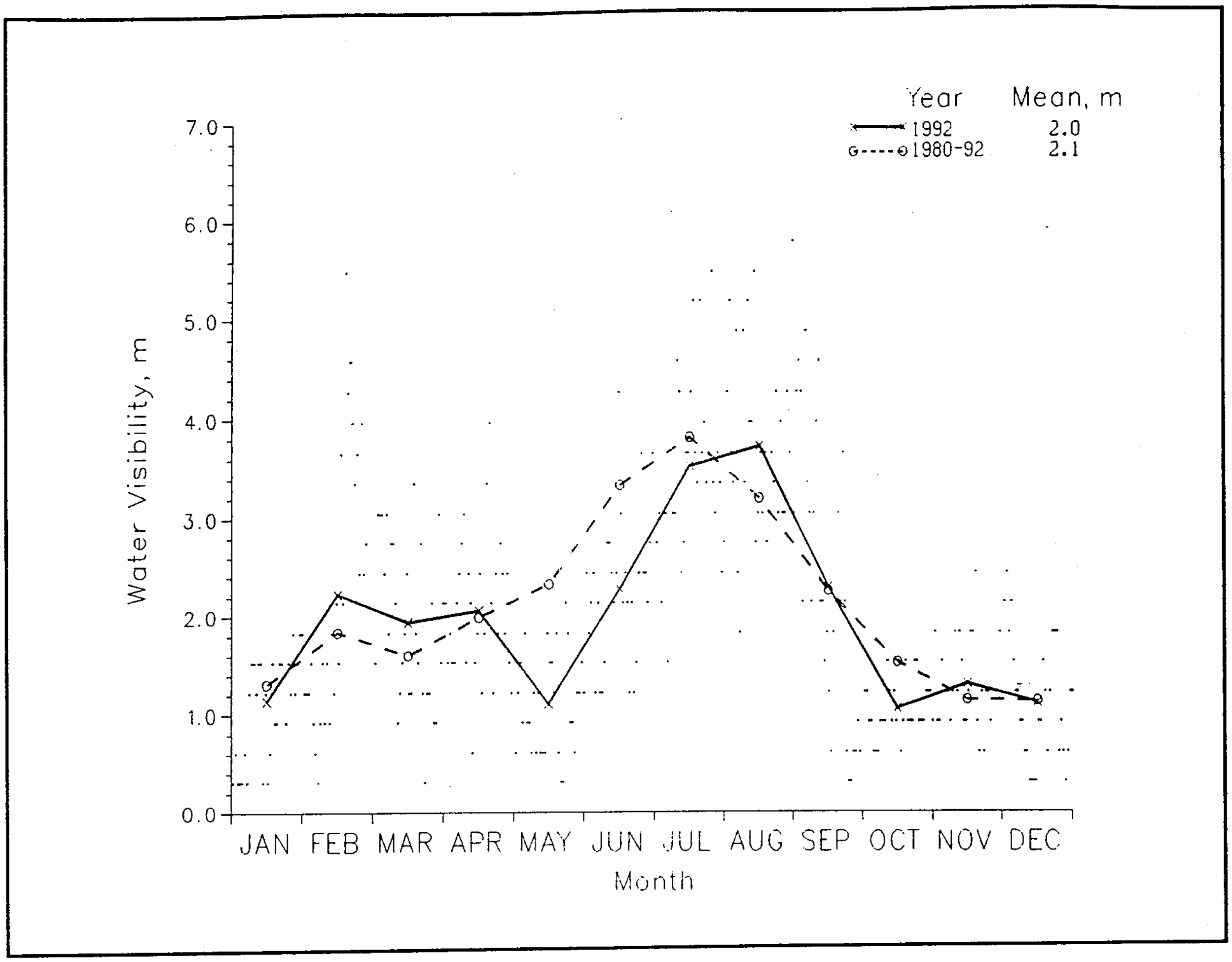


Figure 20. Daily water visibility values with monthly means

Density

Daily and monthly mean surface density values, plotted in Figure 21, were measured with a hydrometer. Monthly means are also given in Table 8.

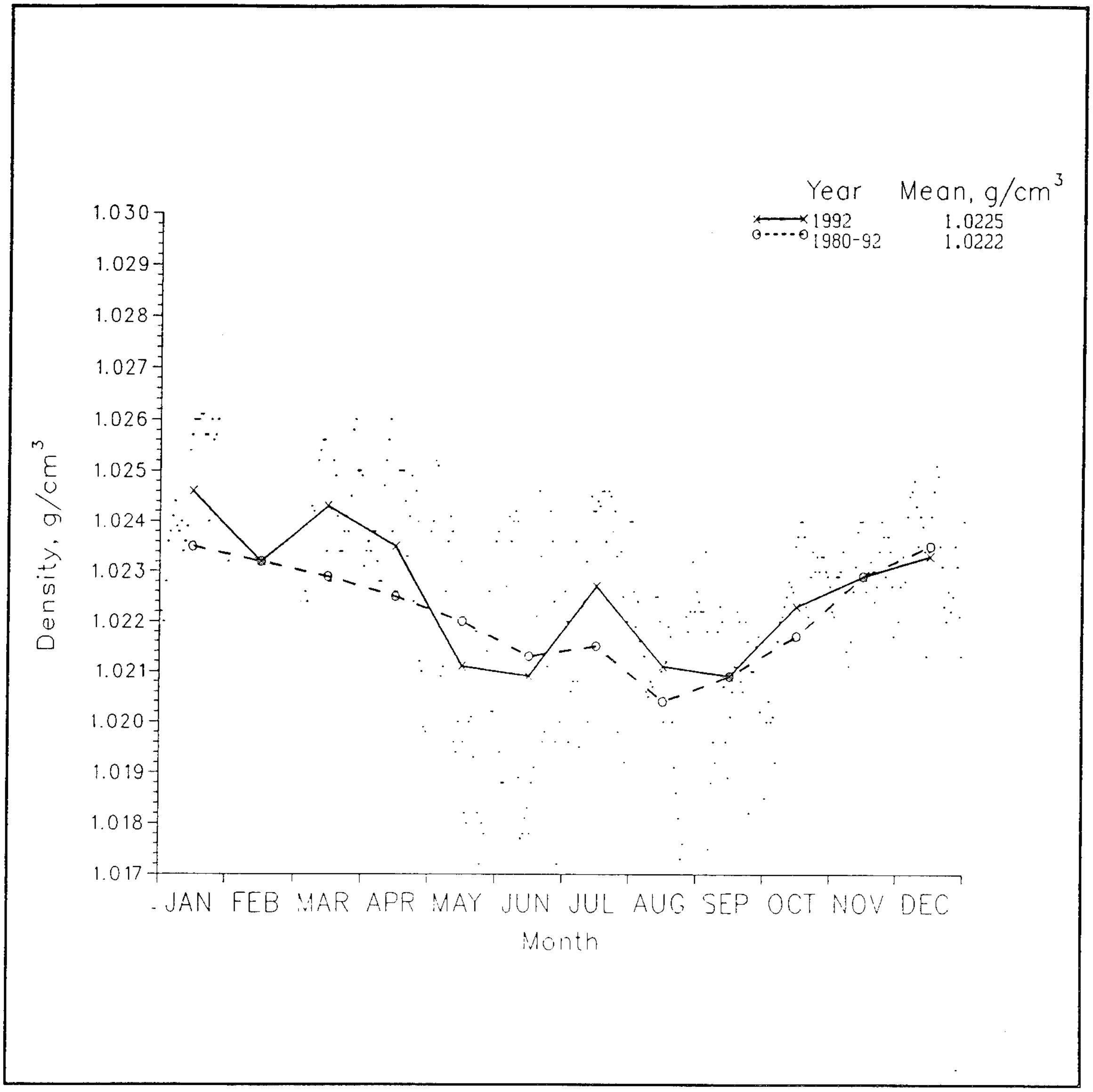


Figure 21. Daily water density values with monthly means

7 Surveys

Waves and currents interacting with bottom sediments produce changes in the beach and nearshore bathymetry. These changes can occur very rapidly in response to storms, or slowly as a result of persistent but less forceful seasonal variations in wave and current conditions.

Nearshore bathymetry at the FRF is characterized by regular shore-parallel contours, a moderate slope, and a barred surf zone (usually an outer storm bar in water depths of about 4.5 m and an inner bar in water depths between 1.0 and 2.0 m). This pattern is interrupted in the immediate vicinity of the pier where a permanent trough runs under much of the pier, ending in a scour hole where depths can be up to 3.0 m greater than the adjacent bottom (Figure 22). This trough, which apparently is the result of the interaction of waves and currents with the pilings, varies in shape and depth with changing wave and current conditions. The effect of the pier on shore-parallel contours occurs as far as 300 m away, and the shoreline may be affected up to 350 m from the pier (Miller, Birkemeier, and DeWall 1983).

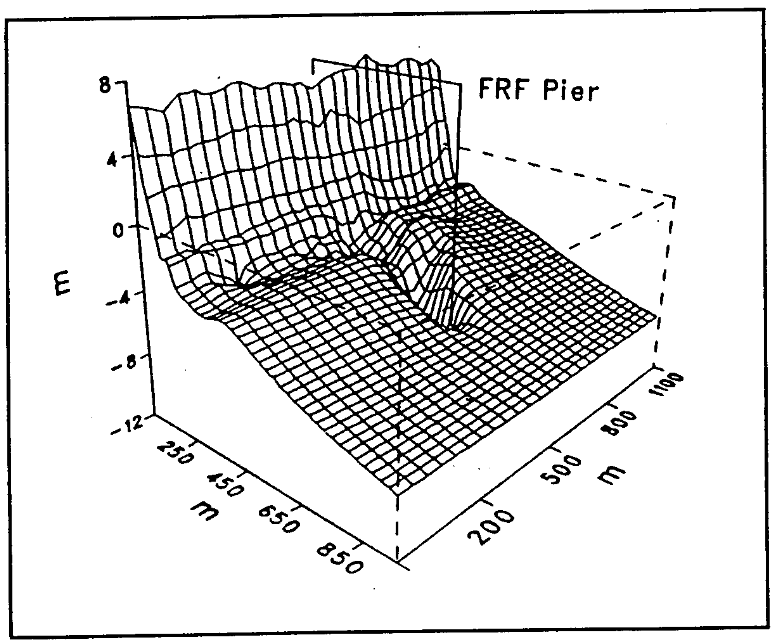


Figure 22. Permanent trough under the FRF pier, 24 January 1992

Approximately once a month, surveys were conducted of an area extending 600 m north and south of the pier and approximately 950 m offshore. These surveys were conducted to document the temporal and spatial variability in bathymetry. Contour maps resulting from these surveys, along with plots of change in elevation between surveys, are given in Appendix A.

All surveys used the Coastal Research Amphibious Buggy (CRAB), a 10.7-m-tall amphibious tripod described by Birkemeier and Mason (1984), and a Geodimeter electronic surveying system, a Geodimeter 140-T self-tracking, electronic theodolite, distance meter. The profile locations are shown in each figure in Appendix A. Monthly soundings along both sides of the FRF pier were collected by lowering a weighted measuring tape to the bottom and recording the distance below the pier deck. Soundings were taken midway between the pier pilings to minimize errors caused by scour near the pilings.

A history of bottom elevations below Gages 645 and 625 is presented in Figure 23 for pier stations 7+80 (238 m) and 18+60 (567 m), along with intermediate locations, 323 and 433 m.

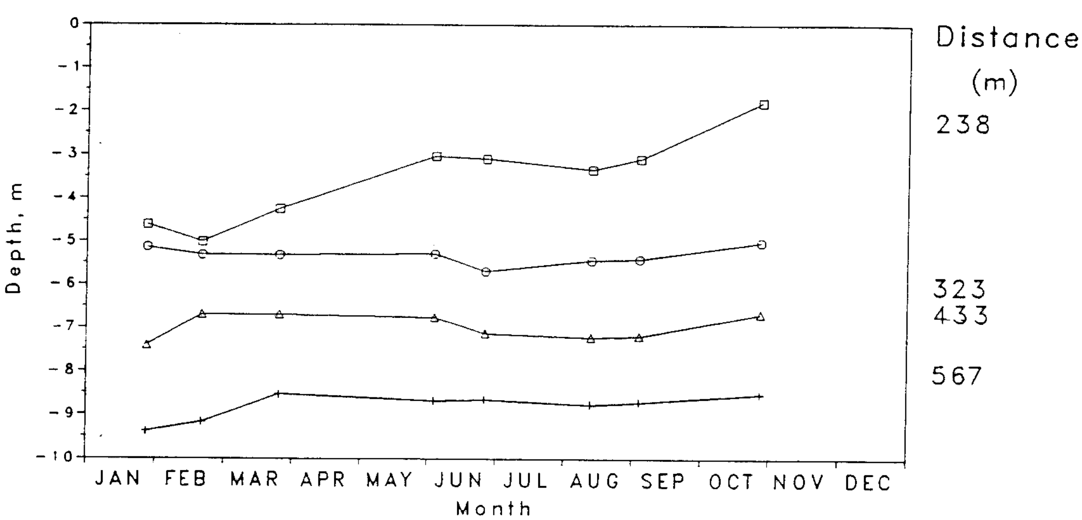


Figure 23. Time-history of bottom elevations at selected locations under the FRF pier

8 Photography

Aerial Photographs

Aerial photographs were taken bi-annually using a 23-cm aerial mapping camera at a scale of 1:12,000. All coverage was at least 60-percent overlap, with flights flown as closely as possible to low tide between 1000 and 1400 EST with less than 10-percent cloud cover. The flight lines covered are shown in Figure 24. Figure 25 is a sample of the imagery obtained on 23 January 1990; the available aerial photographs for the year are:

Date	Flight Lines	Format
17 Jan	1	Black/White
	2	Color
2 Oct	1	Black/White
	2	Color

Beach Photographs

Daily color slides of the beach were taken using a 35-mm camera from the same location on the pier looking north and south (Figure 26). The location from which each picture was taken, as well as the date, time, and a brief description of the picture, were marked on each of the slides.

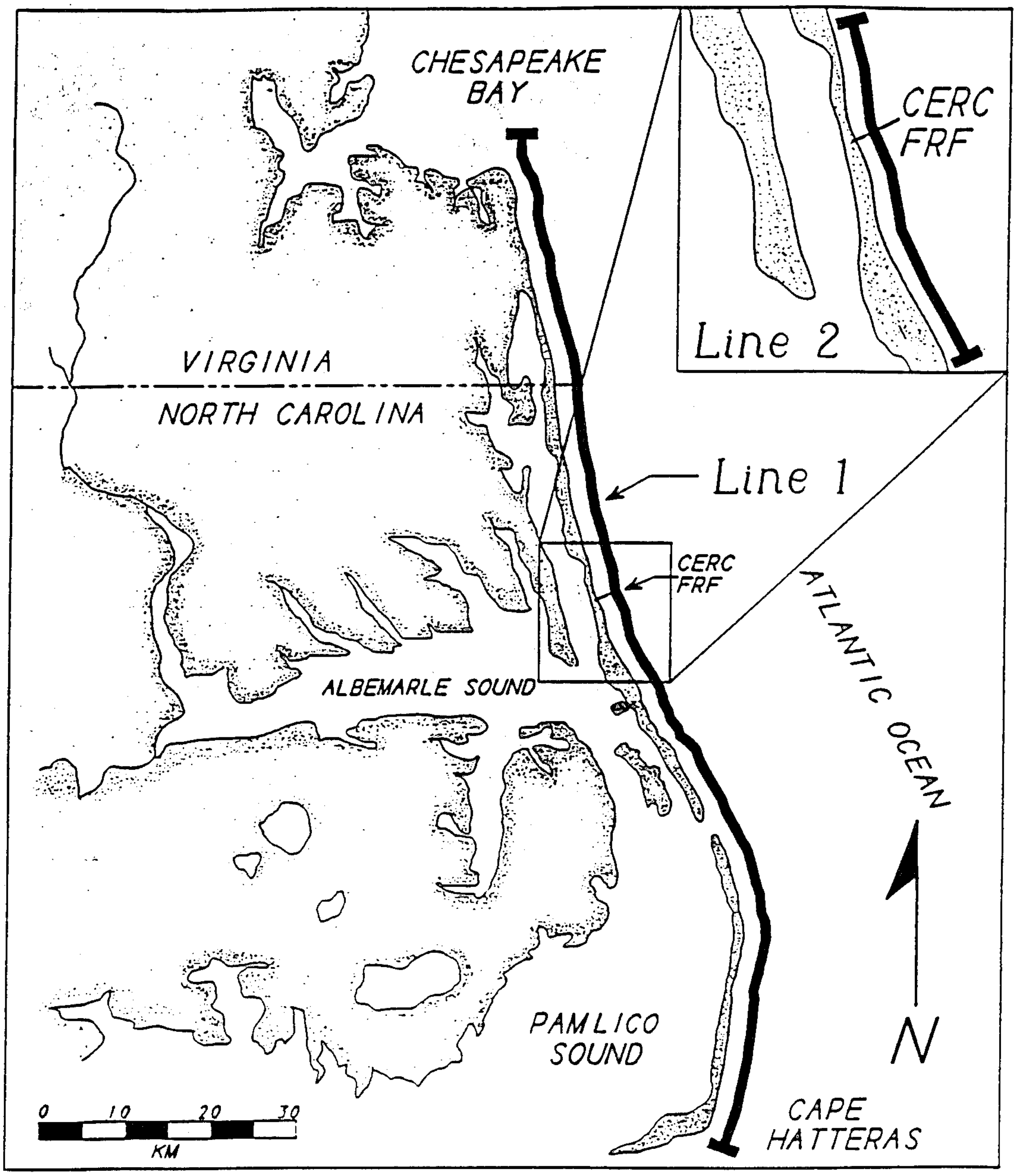


Figure 24. Aerial photography flight lines

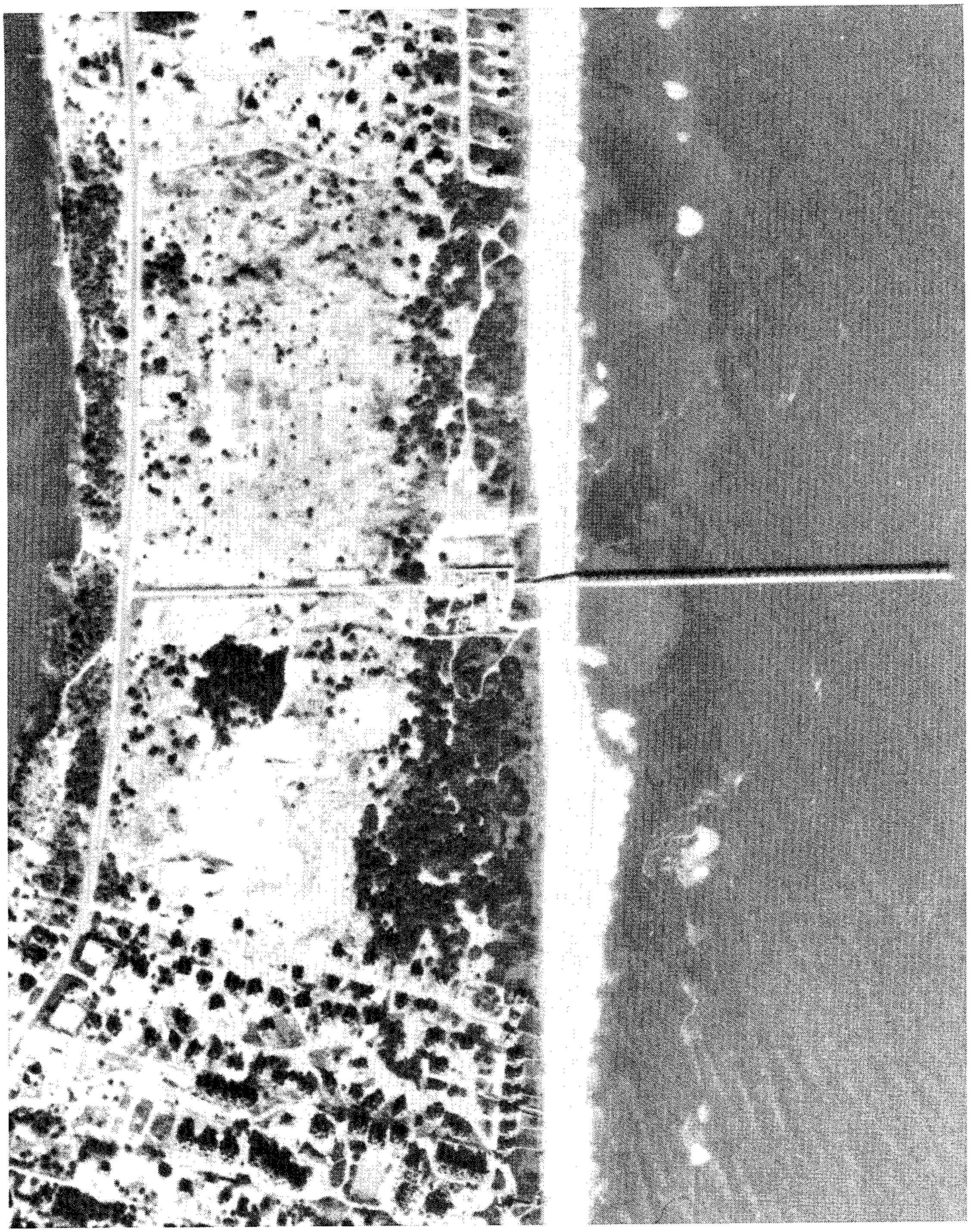
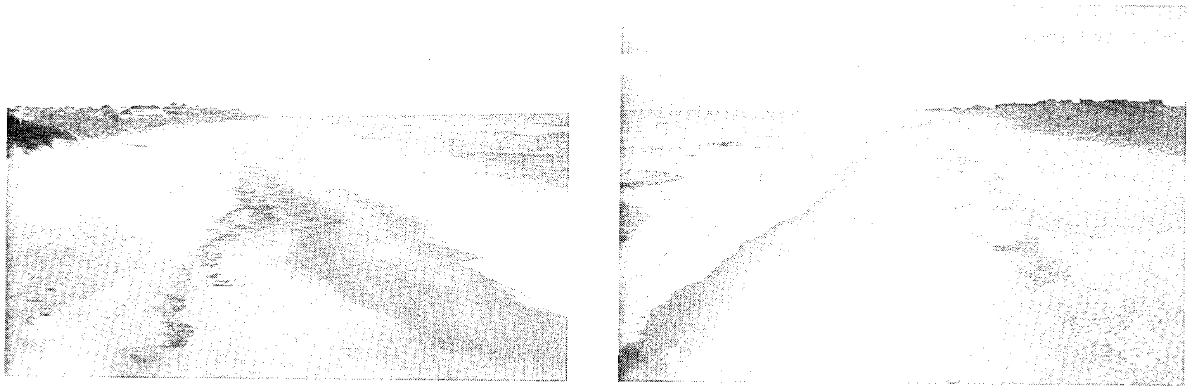
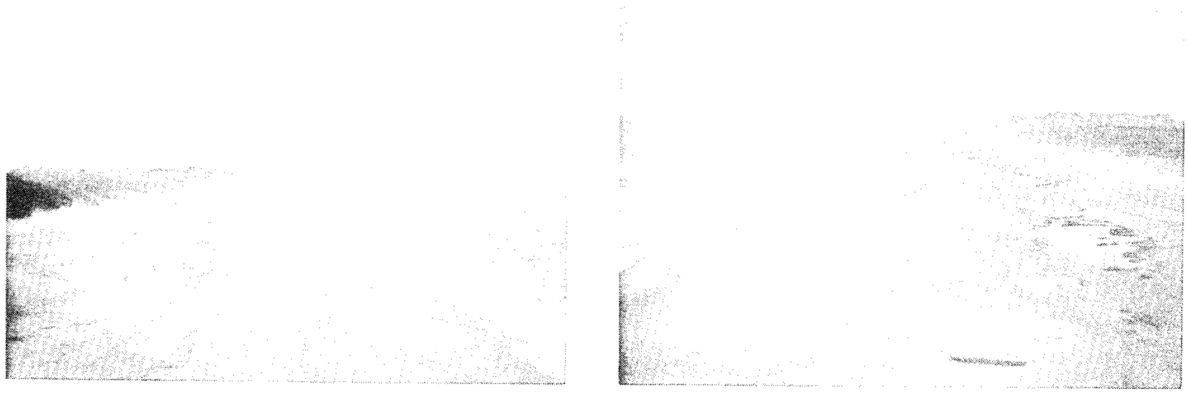


Figure 25. Sample aerial photograph, 14 January 1991 (Scale = 1:12,000)

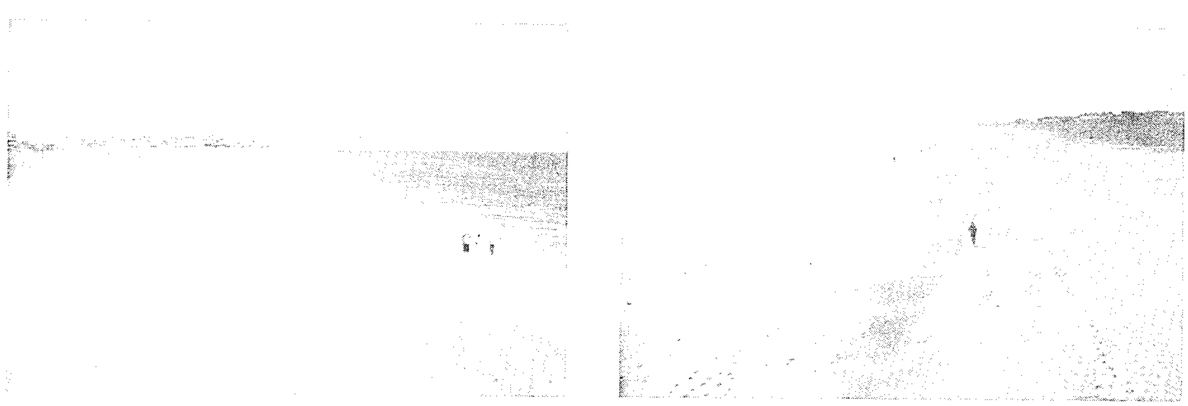
North View | South View



a. 15 January 1992



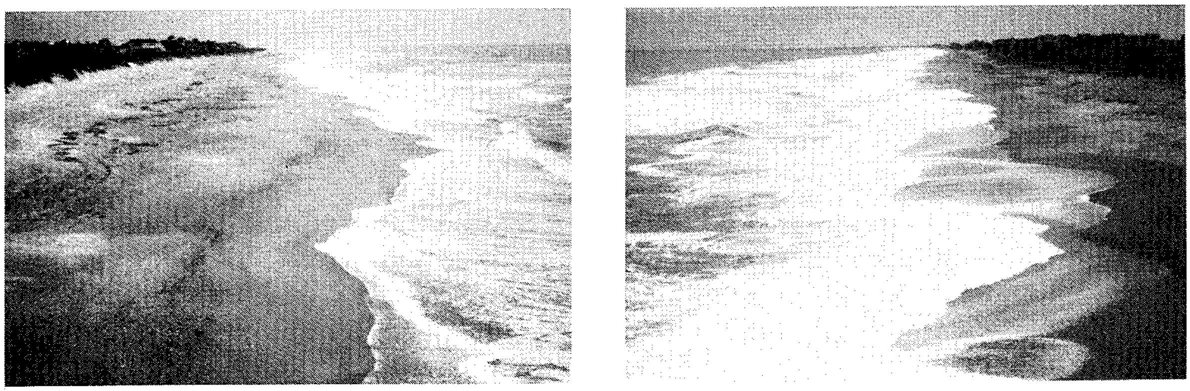
b. 15 February 1992



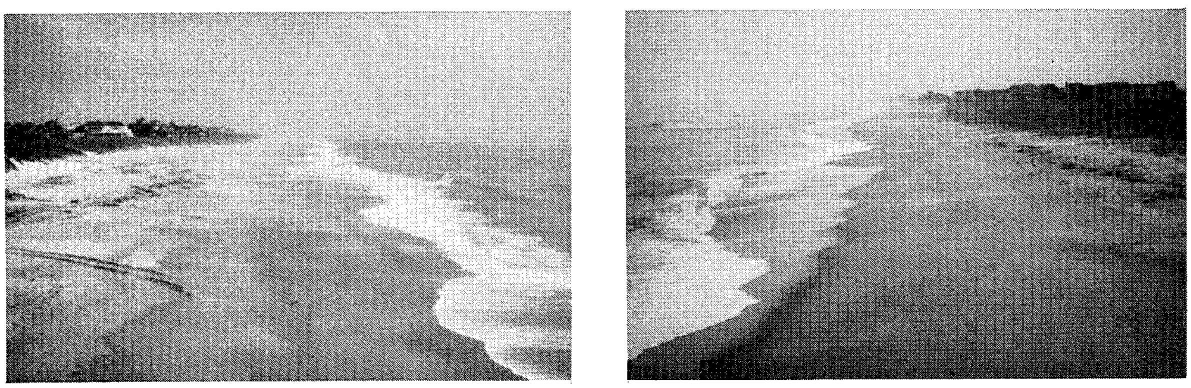
c. 15 March 1992

Figure 26. Beach photos looking north and south from the FRF pier (Sheet 1 of 4)

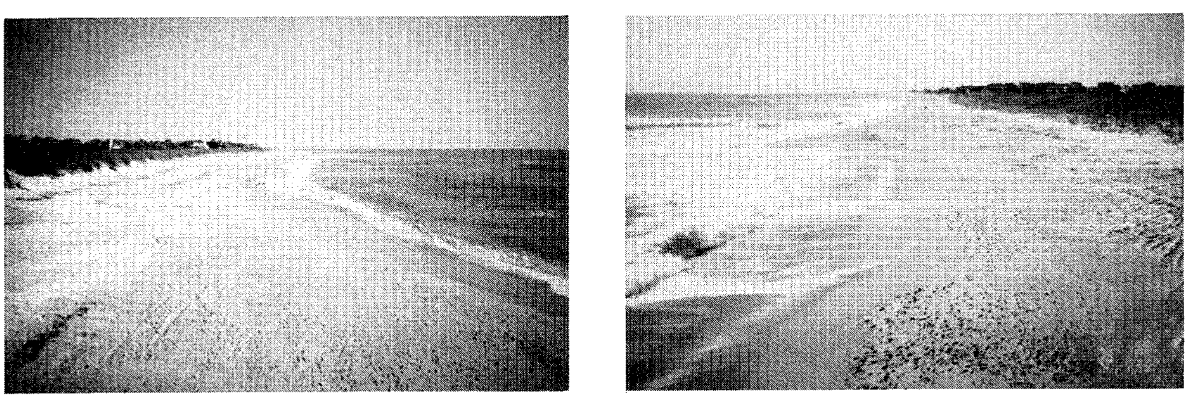
North View South View



d. 15 April 1992



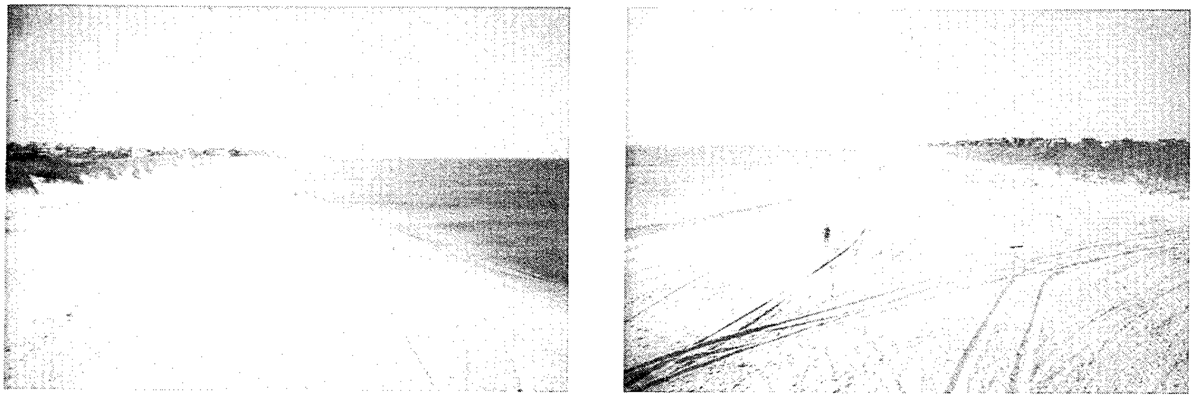
e. 15 May 1992



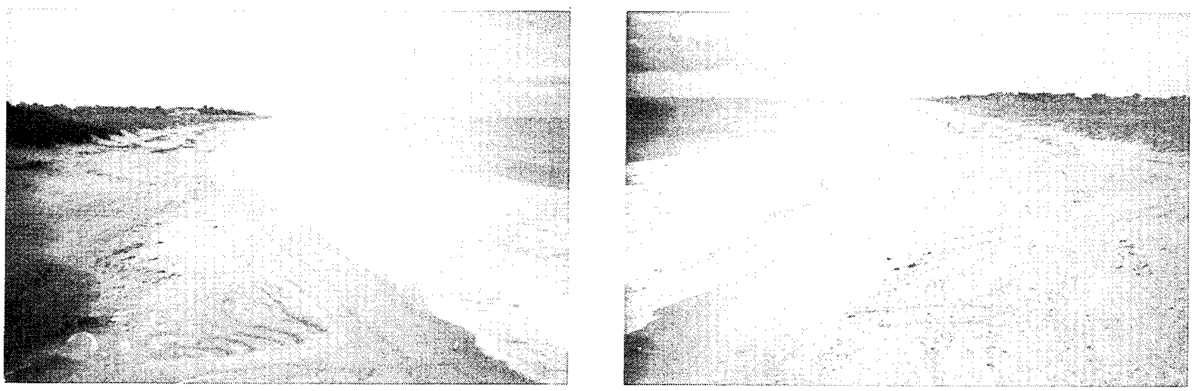
f. 15 June 1992

Figure 26. (Sheet 2 of 4)

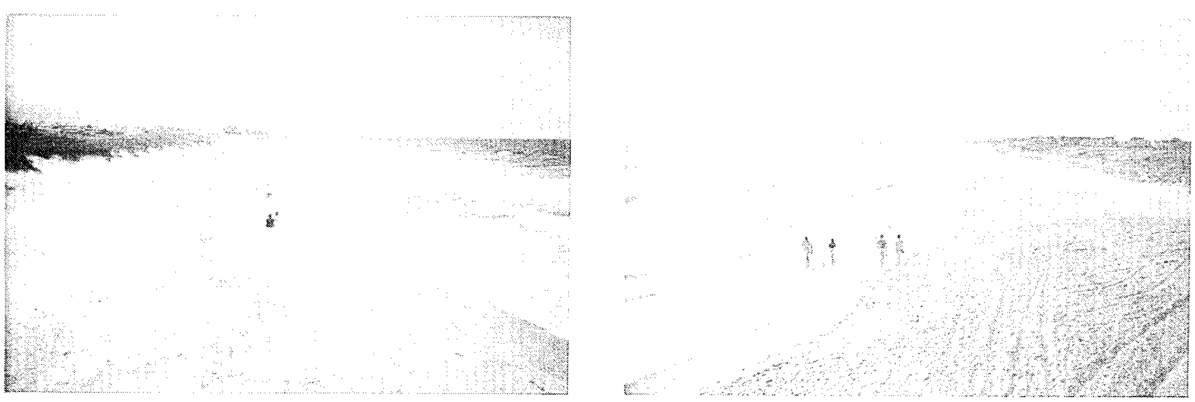
North View South View



g. 15 July 1992



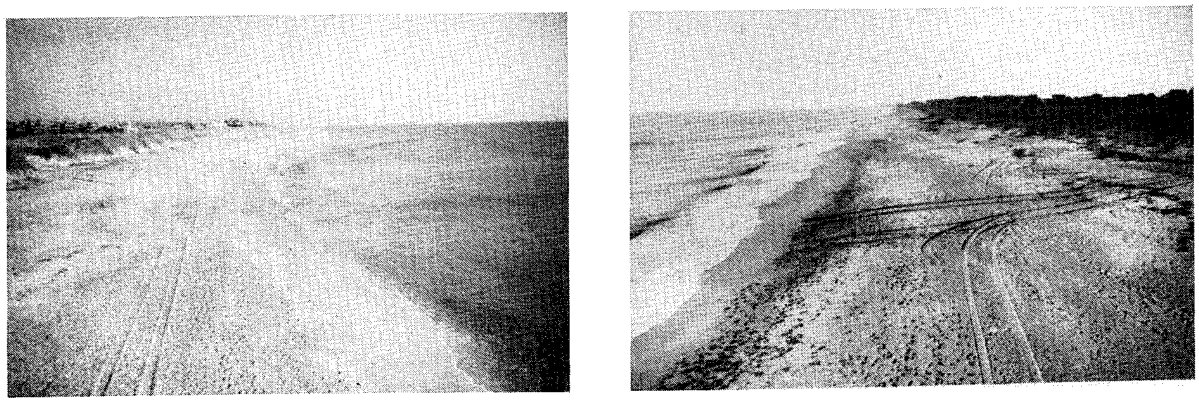
h. 15 August 1992



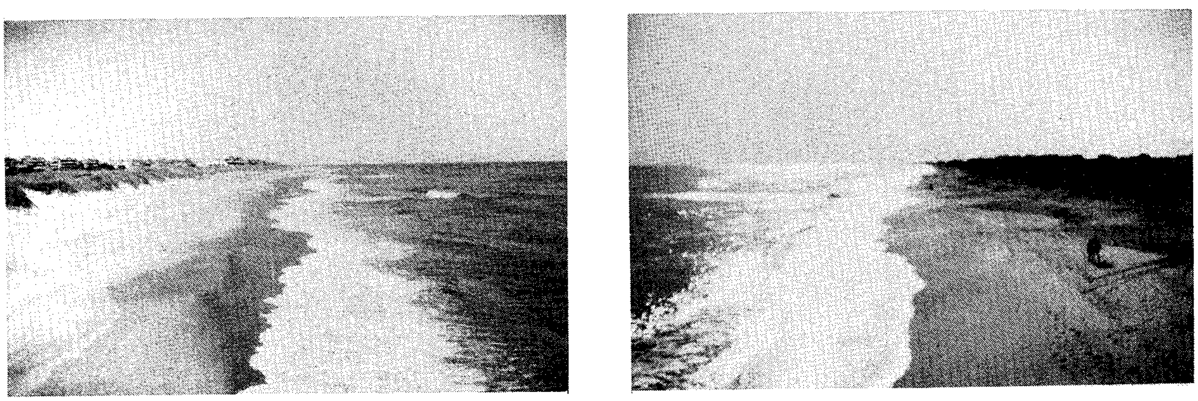
i. 15 September 1992

Figure 26. (Sheet 3 of 4)

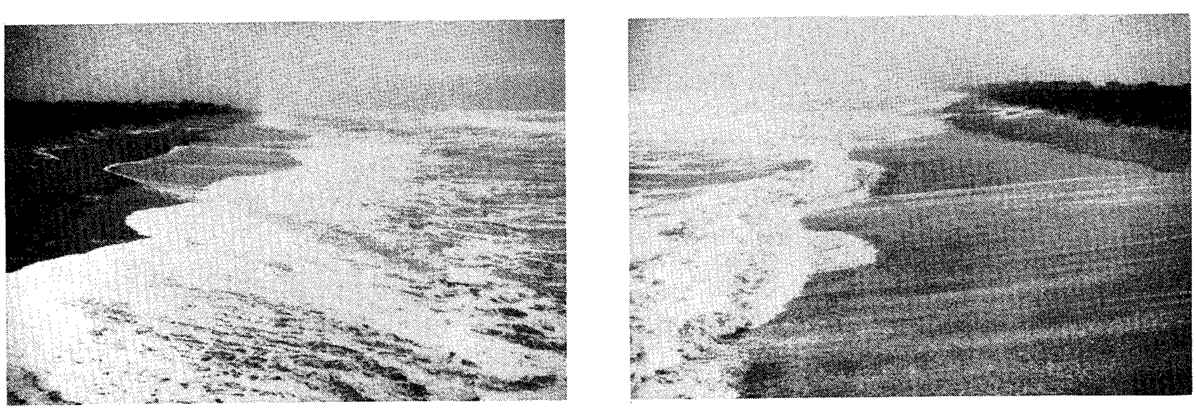
North View South View



j. 15 October 1992



k. 15 November 1992



l. 15 December 1992

Figure 26. (Sheet 4 of 4)

9 Storms

This chapter discusses storms (defined here as times when the wave height parameter H_{mo} equaled or exceeded 2 m at the seaward end of the FRF pier). Sample spectra from Gage 630 are given in Appendix B. Prestorm and/or poststorm bathymetry diagrams are given in Appendix A. Tracking information was provided by NOAA Daily Weather Maps (U.S. Department of Commerce 1992).

3-5 January 1992 (Figure 27)

On 2 January, late in the day, a low pressure system formed off the eastern Florida coast. By 3 January, the storm made landfall on the South Carolina coast. On 4 January, the storm reformed off South Carolina and proceeded north, along the coast, toward New England. The maximum H_{mo}(at gage 111) of 4.3 m (T_p = 13.5 sec) was attained at 0508 EST on 4 January. Maximum winds (from northeast) reached 12.5 m/sec on 3 January at 1742 EST. Total precipitaion was 45 mm.

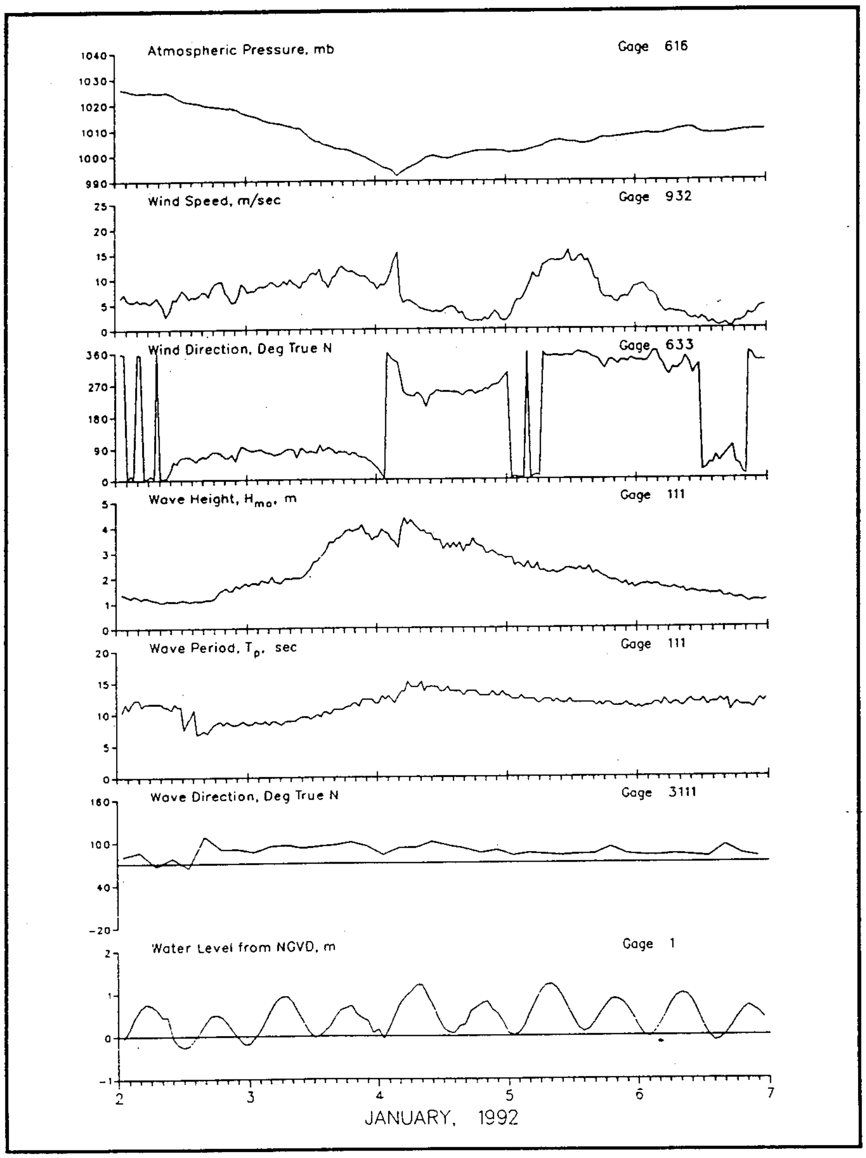


Figure 27. Data for 3-5 January 1992 storm

6-8 February 1992 (Figure 28)

On the morning of 6 February, a low pressure system crossed northern Florida from the Gulf of Mexico to the Atlantic, and headed north along the Atlantic coast. By 7 February, the storm was off the North Carolina coast and was proceeding north toward New England. The maximum H_{mo} (at gage 625) of 2.9 m (T_p = 10.7 sec) was measured at 1034 EST on 7 February. Maximum winds (from northeast) reached 14.3 m/sec on 7 February at 0316 EST. The minimum atmospheric pressure of 996 mb was obtained at 1334 EST also on 7 February. There was no precipitation.

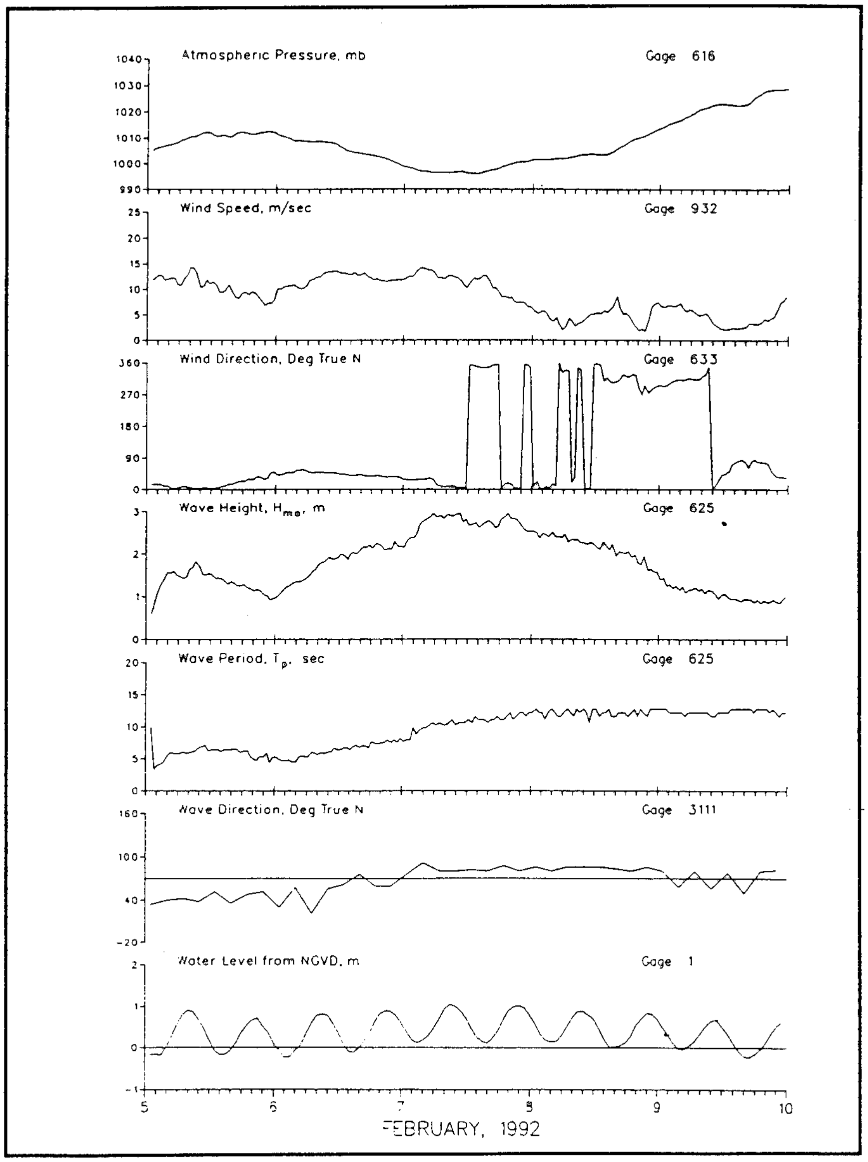


Figure 28. Data for 6-8 February 1992 storm

26-27 March 1992 (Figure 29)

On the morning of 26 March, a low pressure system associated with a cold front, formed along the North Carolina coast. By 27 March, the storm had moved north and inland over New England. The maximum H_{mo} (at gage 625) of 3.2 m (T_p = 11.6 sec) was attained at 1634 EST on 26 March. Maximum winds (from northeast) reached 9.8 m/sec on 26 March at 0842 EST. The minimum atmospheric pressure of 999.4 mb was obtained at 1442 EST also on 26 March. There was 39 mm of precipitation.

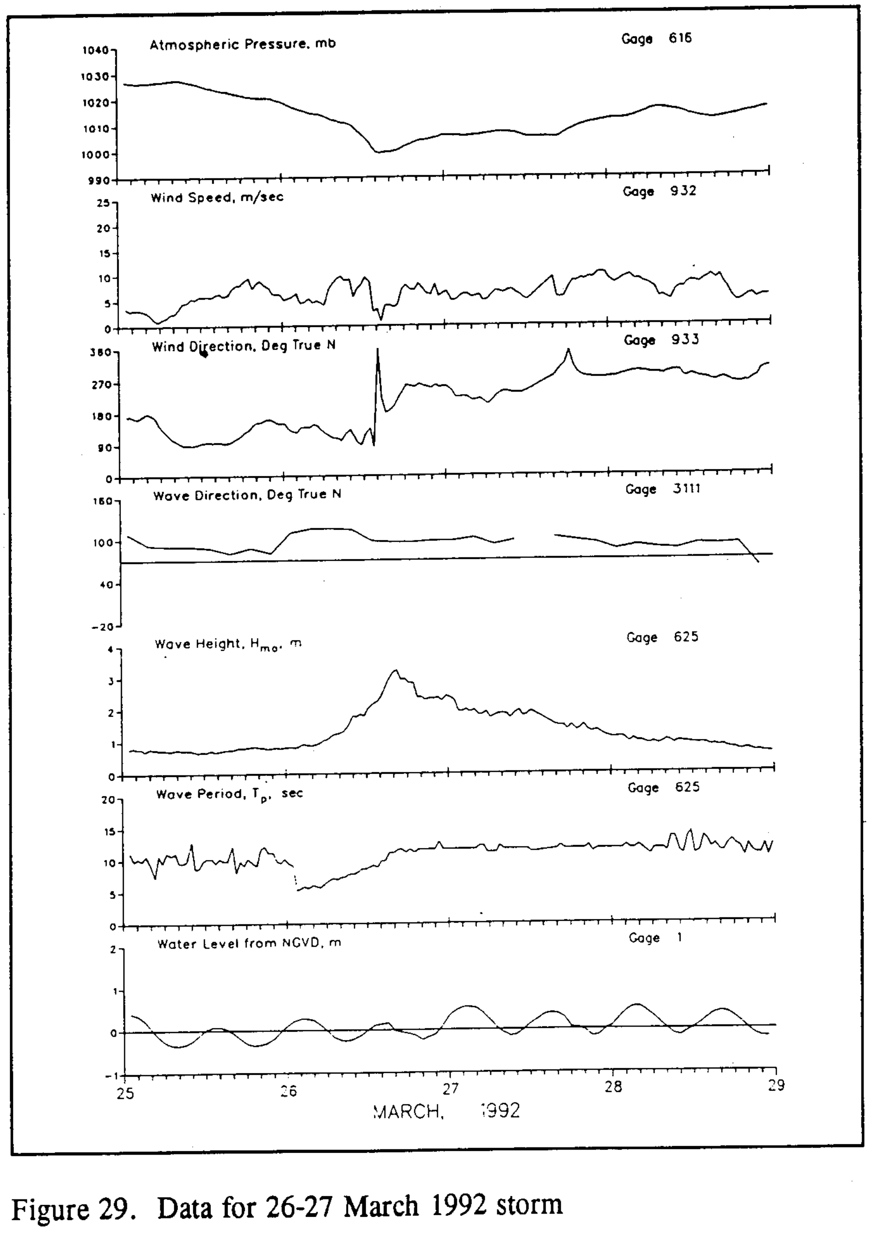


Figure 29. Data for 26-27 March 1992 storm

13 April 1992 (Figure 30)

A low pressure system formed off the Florida coast and headed seaward. The maximum H_{mo} (at gage 625) of 2.6 m (T_p = 7.0 sec) was measured at 0842 EST on 13 April. Maximum winds (from northeast) reached 15.5 m/sec on 13 April at 0616 EST. Atmospheric pressure was not affected due to the storm system remaining well offshore. There was no precipitation.

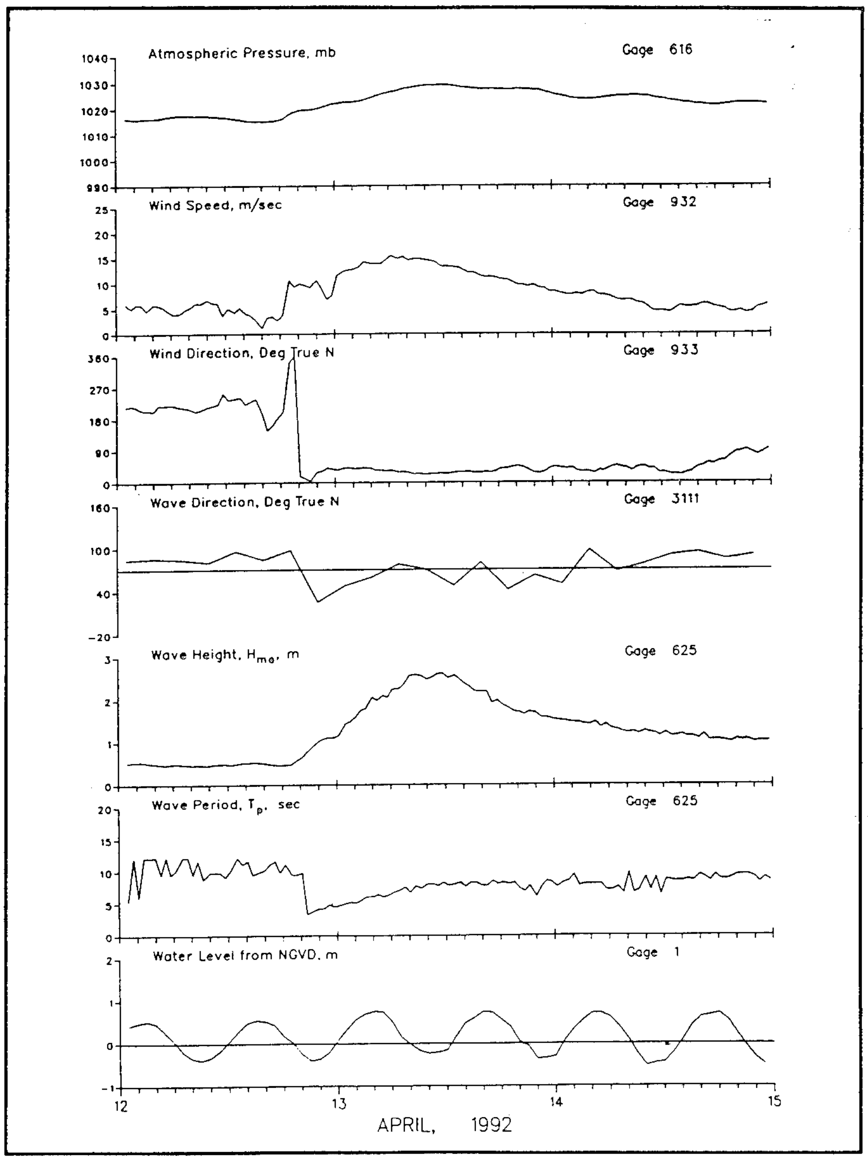


Figure 30. Data for 13 April 1992 storm

28-30 April 1992 (Figure 31)

A low pressure system formed off the Carolina coast and headed seaward. The maximum H_{mo} (at gage 625) of 2.6 m (T_p = 10.2 sec) was measured at 1108 EST on 29 April. Maximum winds (from northeast) reached 15.0 m/sec on 29 April at 0542 EST. Atmospheric pressure was not affected during either storm due to the storm system remaining well offshore. There was no precipitation.

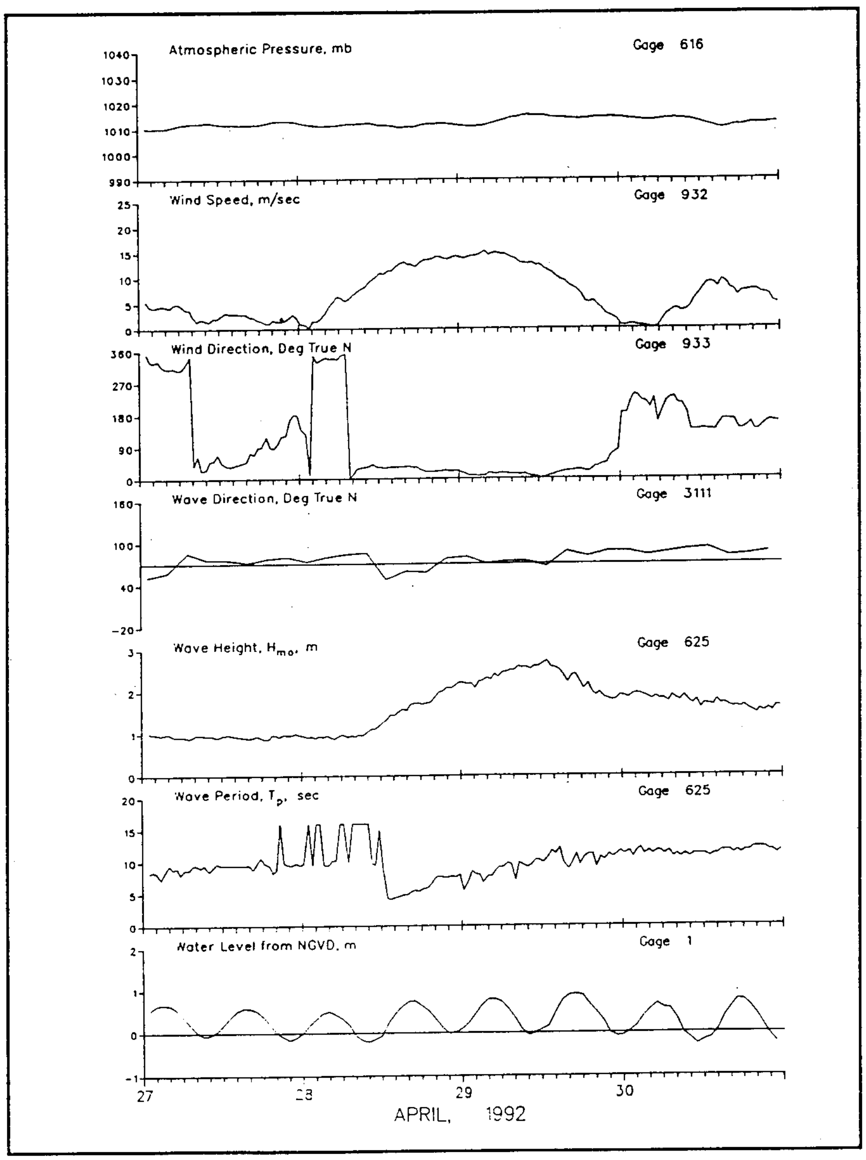


Figure 31. Data for 28-30 April 1992 storm

6-8 May 1992 (Figure 32)

A low pressure system, associated with a cold front, formed along the Florida-Georgia coast remaining stationary through the morning of 7 May. By the morning of 8 May the storm had made landfall along the southern coast of North Carolina and headed inland. The maximum H_{mo} (at gage 625) of 3.0 m (T_p = 9.9 sec) was attained at 0842 EST on 7 May. Maximum winds (from northeast) reached 17.7 m/sec on 7 May at 1000 EST. Atmospheric pressure was unaffected. There was 38 mm of precipitation.

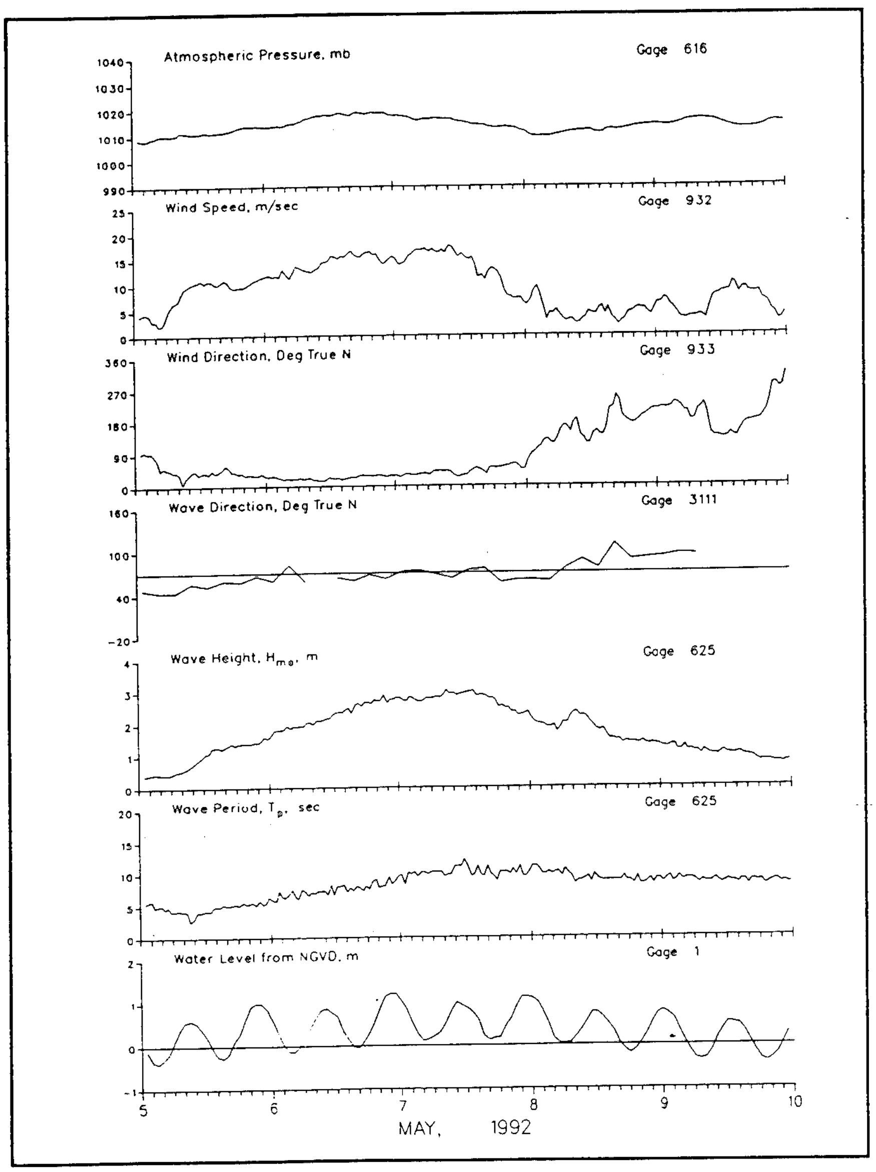


Figure 32. Data for 6-8 May 1992 storm

19-20 May 1992 (Figure 33)

Winds associated with a Canadian high pressure system generated these storm waves. The maximum H_{mo} (at gage 625) of 2.1 m (T_p = 8.8 sec) was attained at 2200 EST on 19 May. Maximum winds (from northeast) reached 13.9 m/sec on 19 May at 1816 EST.

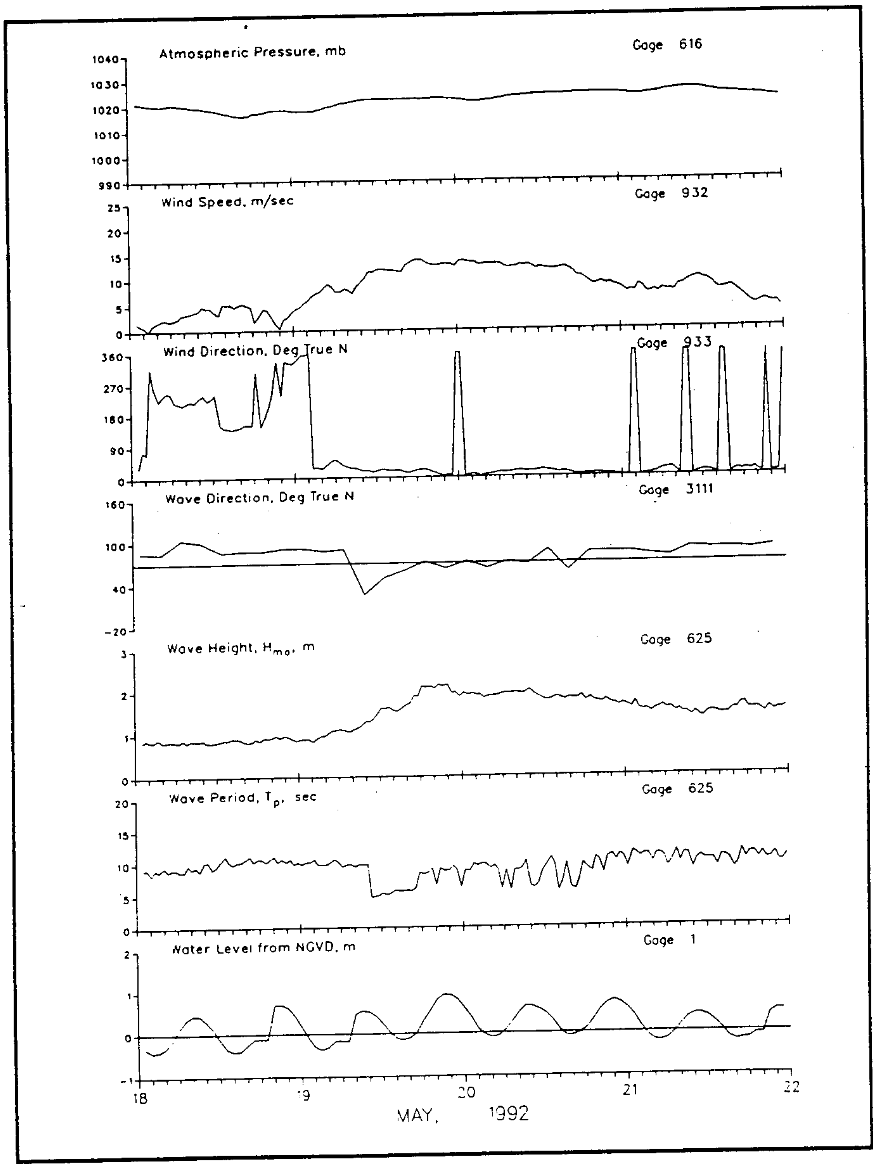


Figure 33. Data for 19-20 May 1992 storm

23 September 1992, Tropical Storm Danielle (Figure 34)

A tropical depression had developed off the North Caroloina - South Carolina coast by the morning of 22 September. It tracked to the north, parallel to shore and by the morning of 23 September had intensified into a tropical storm located about 200 km southeast of Cape Hatteras. Interaction with a cold front caused Danielle to head onshore and the storm made landfall along the northeastern coast of North Carolina on the morning of 25 September, as it continued to move north along the Atlantic shore. The maximum H_{mo} (at gage 630) of 4.6 m (T_p = 9.5 sec) was measured at 0734 EST on 25 September. Maximum winds (from northeast) reached 20.5 m/sec on 25 September at 0542 EST. Winds were sustained above 15 m/sec from 23 September through the early morning of 25 September. The minimum atmospheric pressure of 1010.8 mb was measured at 0842 also on 25 September. There was 15 mm of precipitation.

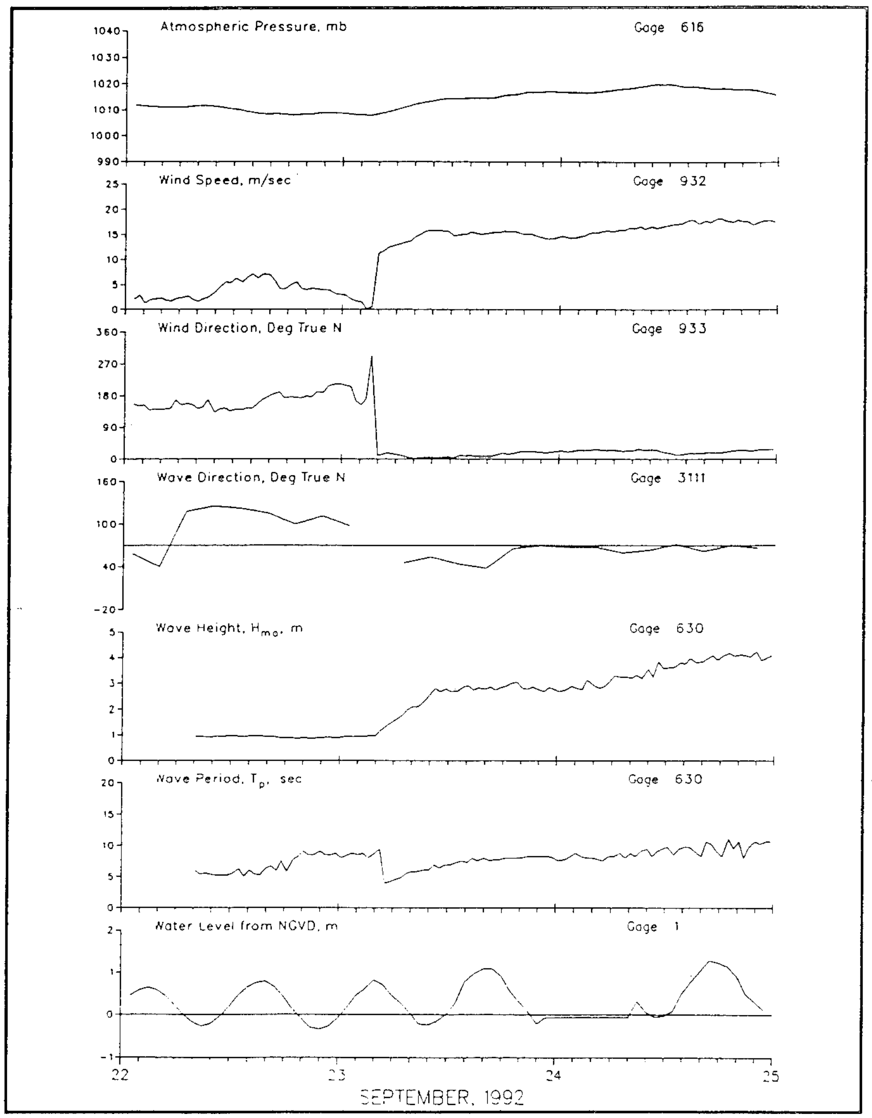


Figure 34. Data for 23 September 1992 (Tropical Storm Danielle) storm

4-6 October 1992 (Figure 35)

A low pressure system that was funneled northward from the Gulf of Mexico between two cold fronts passed about 240 kms east of Cape Hatteras. The maximum H_{mo} (at gage 625) of 3.1 m (T_p = 10.2 sec) was attained at 1216 EST on 5 October. Maximum winds (from northeast) reached 19.1 m/sec on 5 October at 0734 EST. Atmospheric pressure was recorded at a low of 1004.5 mb. There was 28 mm of precipitaion.

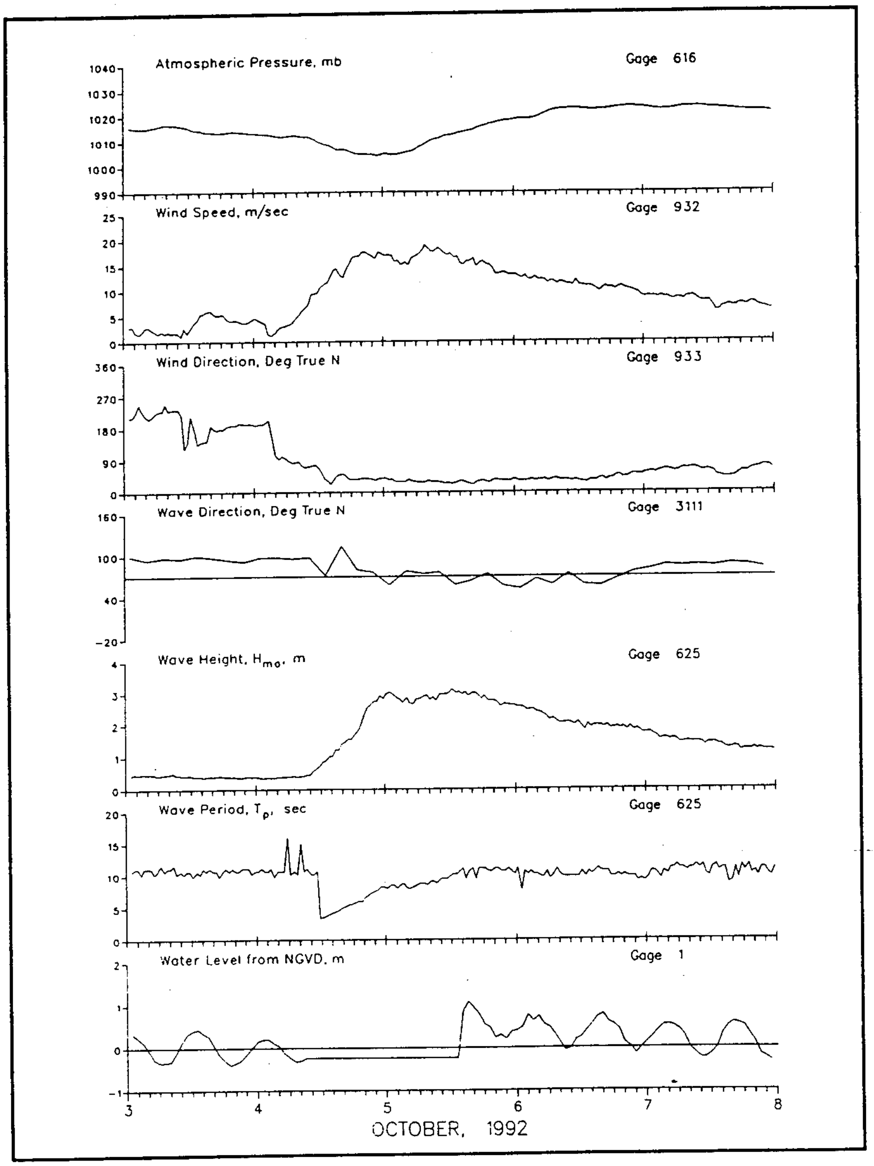


Figure 35. Data for 4-6 October 1992 storm

10-11 December 1992 (Figure 36)

Strong onshore winds were funnelled northward between a high pressure system to the northeast of the FRF and a low pressure system to the southwest of the FRF. The atmospheric pressure fell from 1021 mb at 0100 EST on 10 December, to 994 mb by the end of the day as the storm moved over Delaware. The maximum H_{mo} at gage 630 was 4.4 m (T_p = 11.13 sec) at 2116 EST. Maximum onshore winds reached 19 m/sec from the southeast at 1634 EST. There was 31 mm of precipitation.

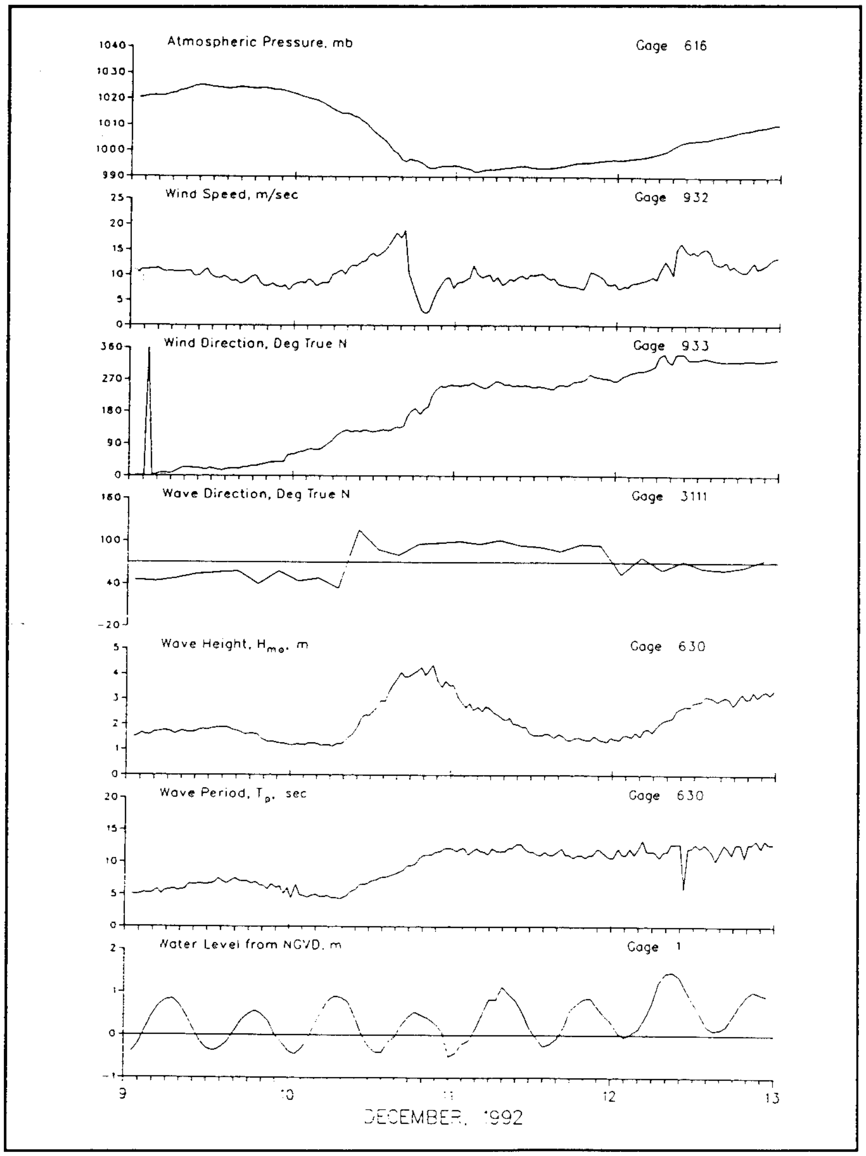


Figure 36. Data for 10-11 December 1992 storm

12-16 December 1992 (Figure 37)

The 11 December storm system continued its northeast course until 12 December when it was located approximately 400 km off the New Jersey coast. At this time, the storm had evolved into a strong northeaster with the major impact of the storm well to the north of the FRF. Winds increased at the FRF as the storm moved to the southeast. By 13 December it was located about 500 km off the Delaware coast. At this time the FRF was receiving northerly winds. There were no onshore winds, but waves generated by the storm reached a maximum H_{mo} at gage 630 of 4.7 m (T_p = 17.1 sec) at 1408 EST on 14 December. The atmospheric pressure remained steady around 1017 mb. There was 5 mm of precipitation. By 15 December the storm was headed out to sea.

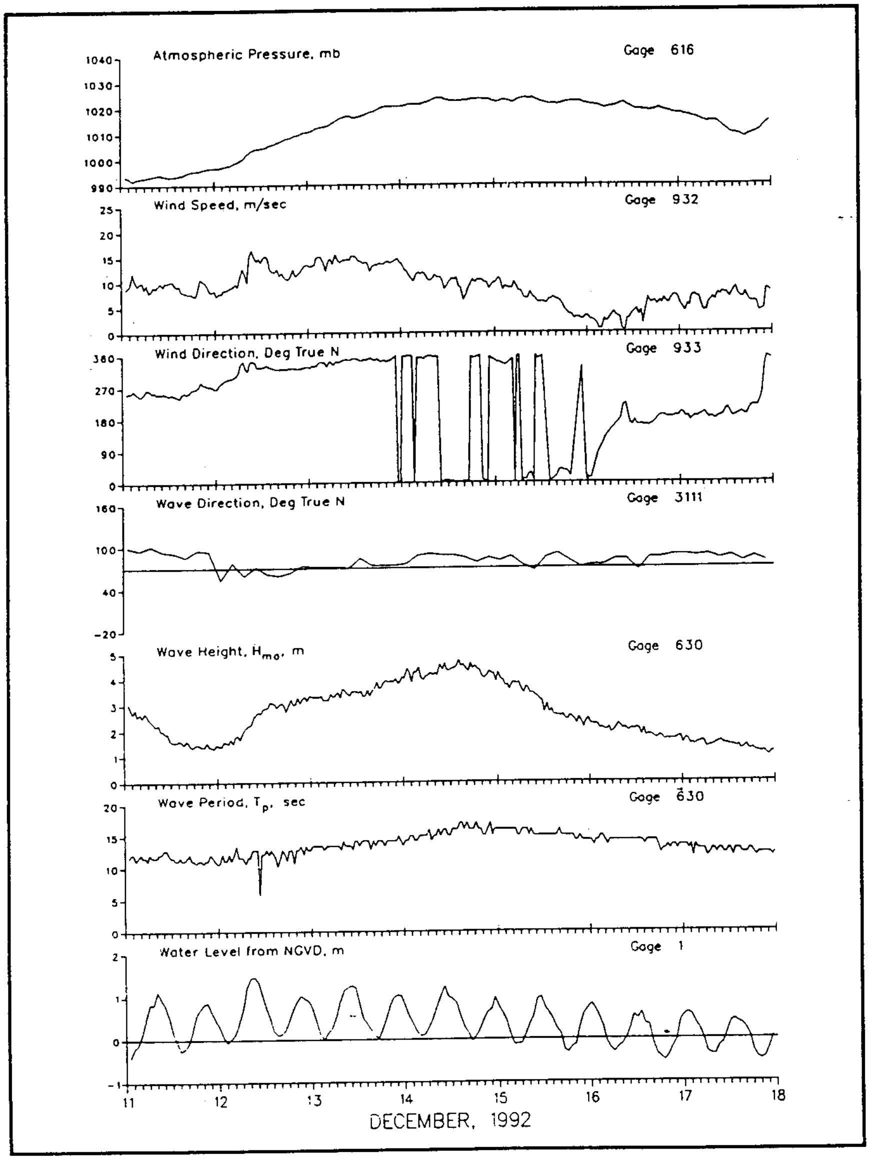


Figure 37. Data for 12-16 December 1992 storm

29 December 1992 (Figure 38)

Developing just off the northeastern coast of Florida on the morning of 28 December this small coastal storm slowly moved up the east coast being to just off Cape Hatteras, NC, on the morning of 29 December. Rapidly picking up speed the storm was located off the Maine coast early the next day. The maximum H_{mo} at gage 625 was 2.45 m (T_p = 9.84 sec) at 0734 EST. Onshore winds reached 11 m/sec at 1900 on 28 December. Atmospheric pressure remained steady around 1022 mb. There was 9 mm of precipitation.

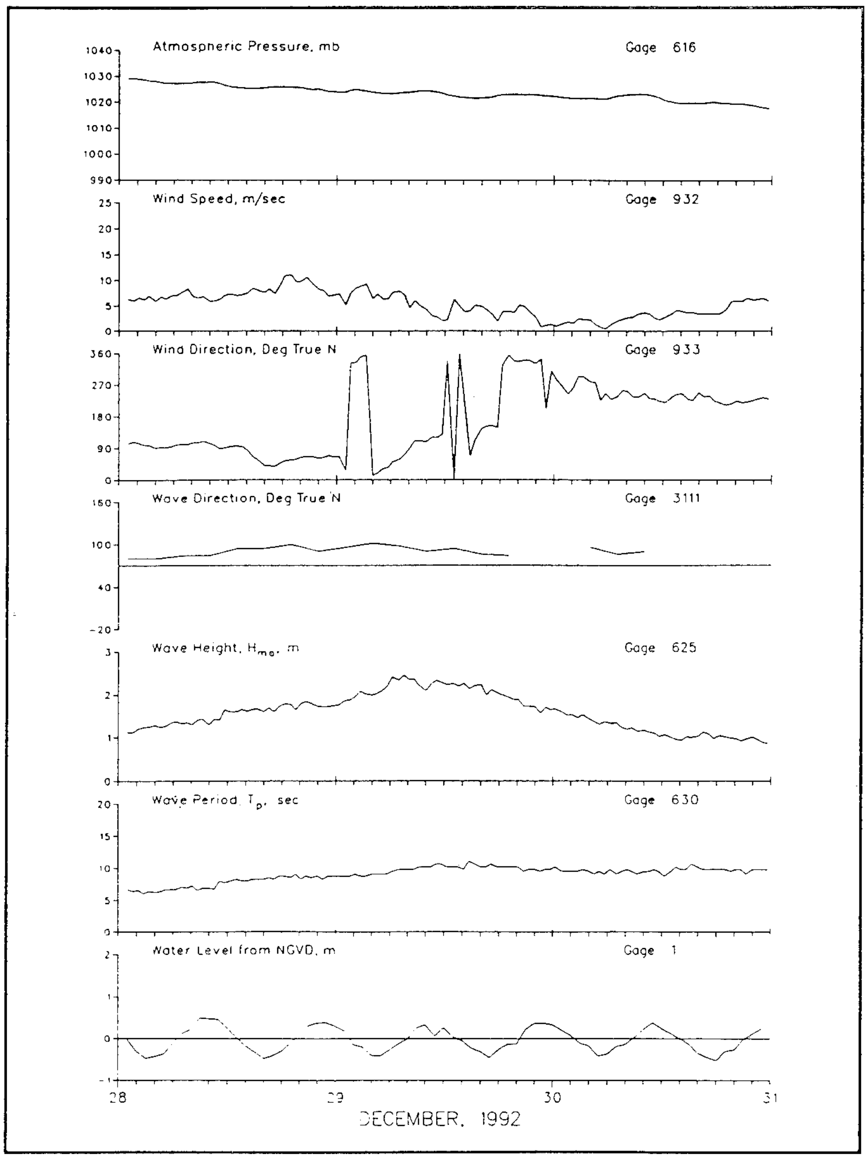


Figure 38. Data for 29 December 1992 storm

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Appendix A
Survey Data

Contour diagrams constructed from the bathymetric survey data are presented in this appendix. The profile lines surveyed are identified on each diagram. Contours are in half-meter increments referenced to NGVD. The distance offshore is referenced to the FRF monumentation baseline behind the dune.

Changes in FRF bathymetry diagrams constructed by contouring the difference between two contour diagrams are also presented with contour intervals of 0.25 m. Wide contour lines show areas of erosion. Other areas correspond to areas of accretion. Although these change diagrams are based on considerable interpolation of the original survey data, they do facilitate comparison of the contour diagrams.

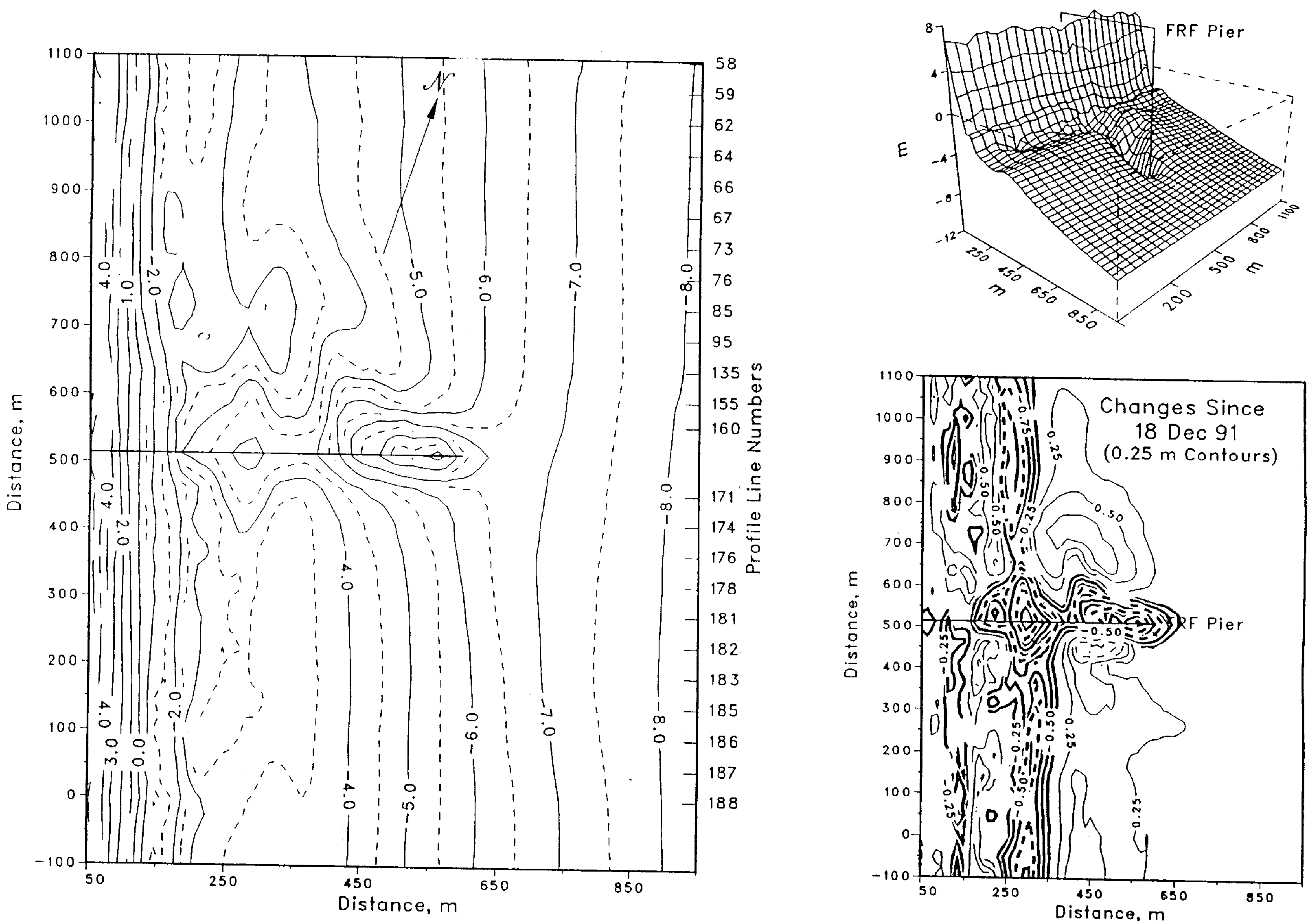


Figure A1. FRF Bathymetry, 24 January 92 (depths relative to NGVD)

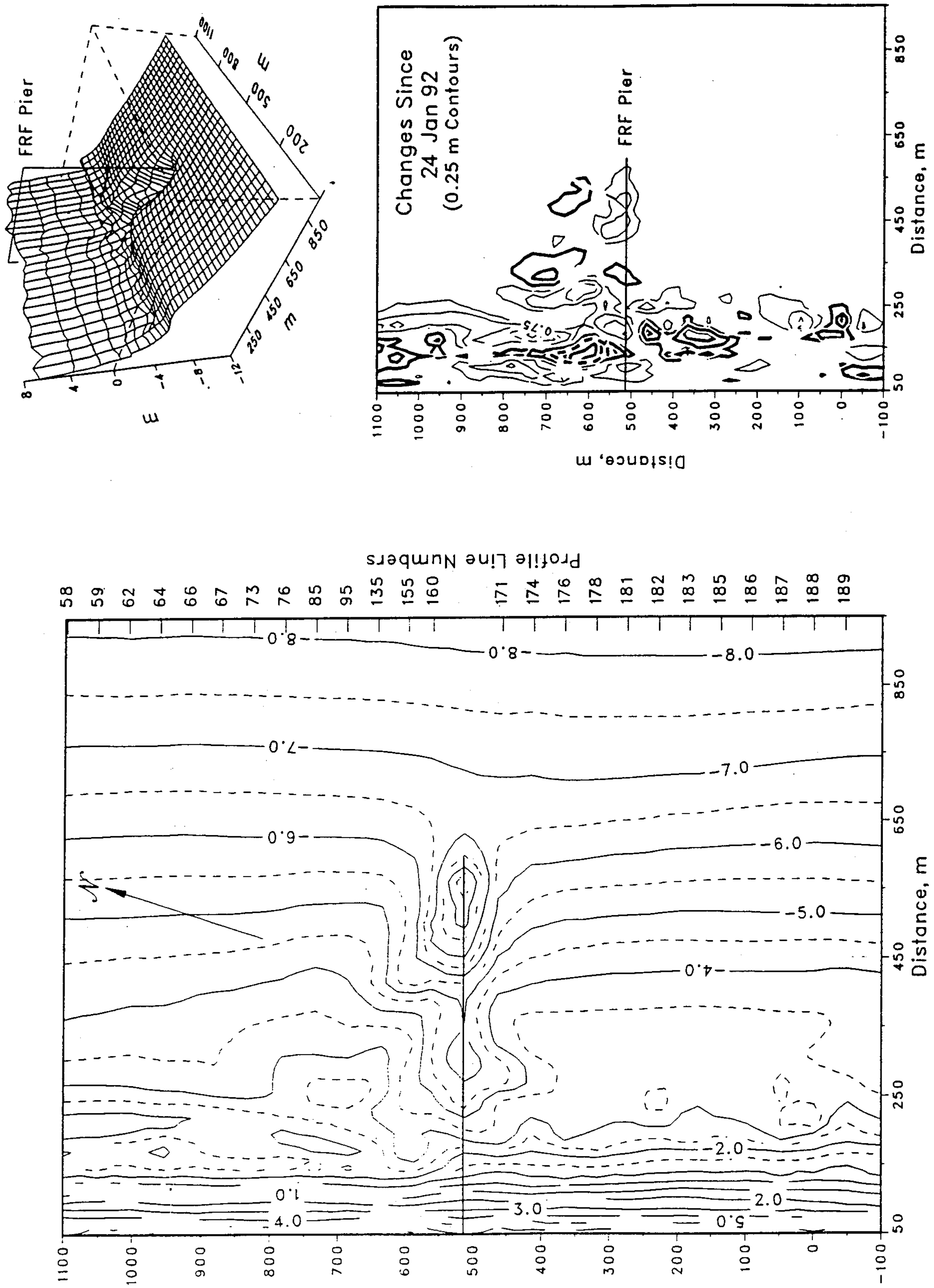


Figure A2. FRF Bathymetry, 11 February 92 (depths relative to NGVD)

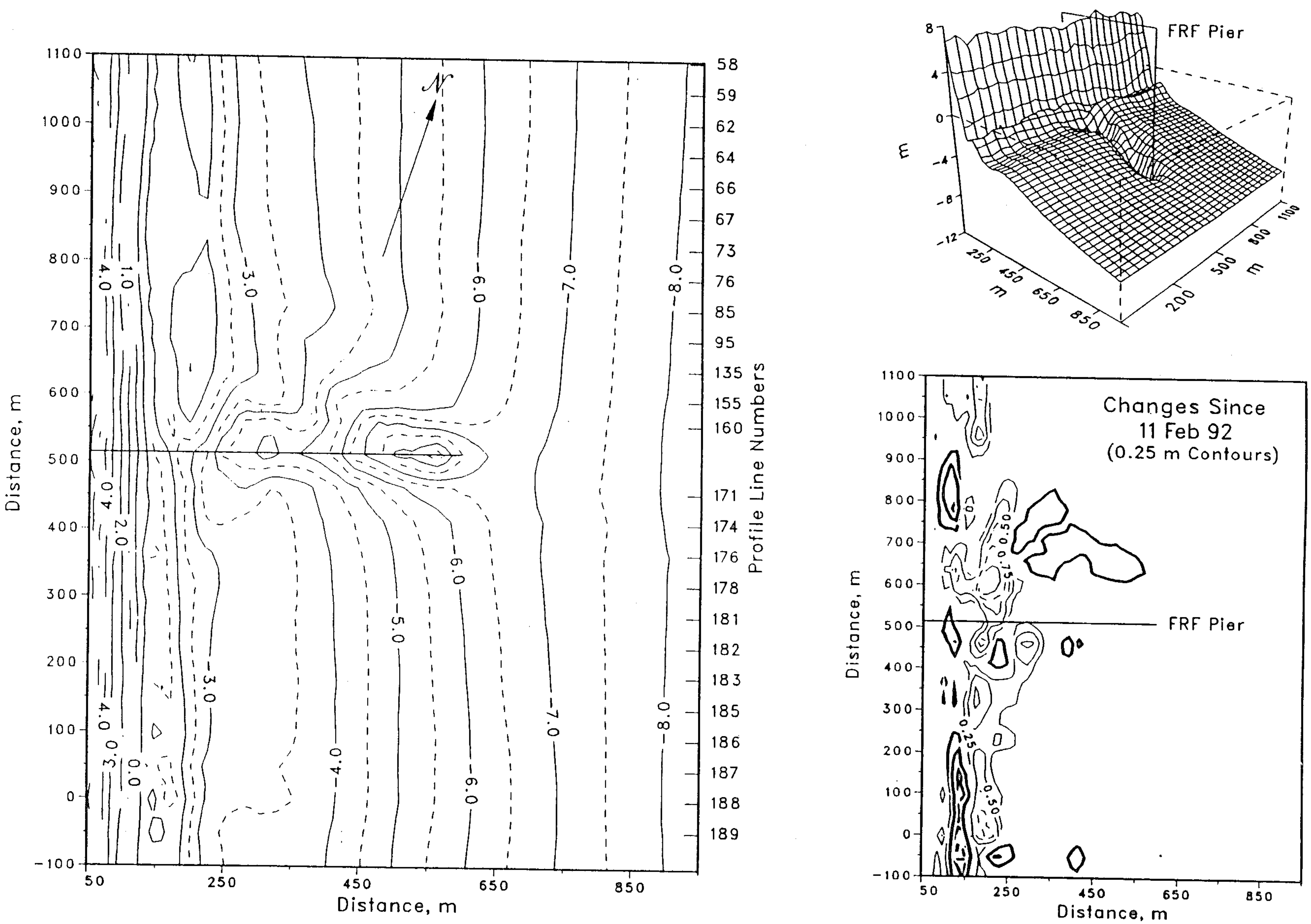


Figure A3. FRF Bathymetry, 25 March 92 (depths relative to NGVD)

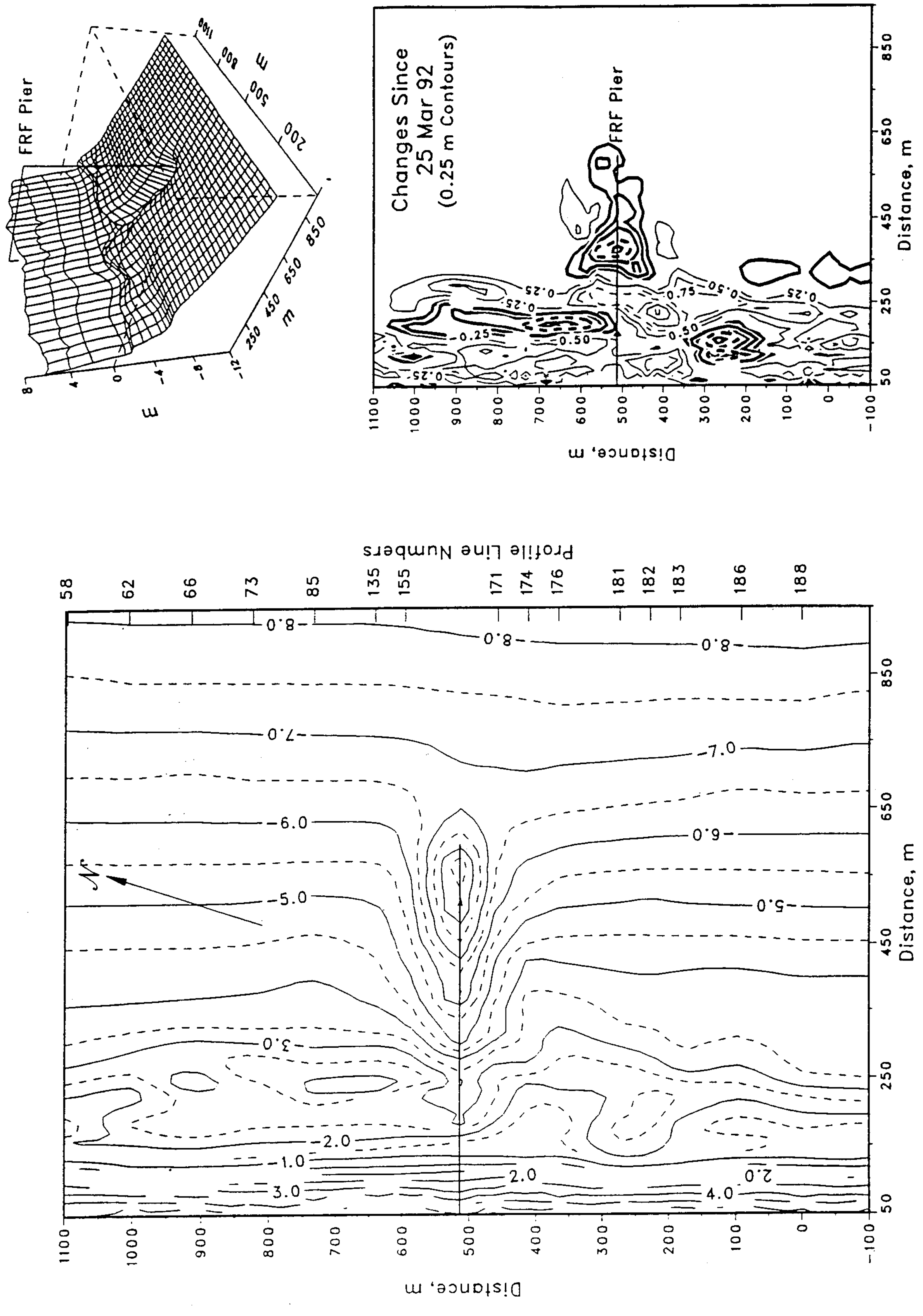


Figure A4. FRF Bathymetry, 28 May 92 (depths relative to NGVD)

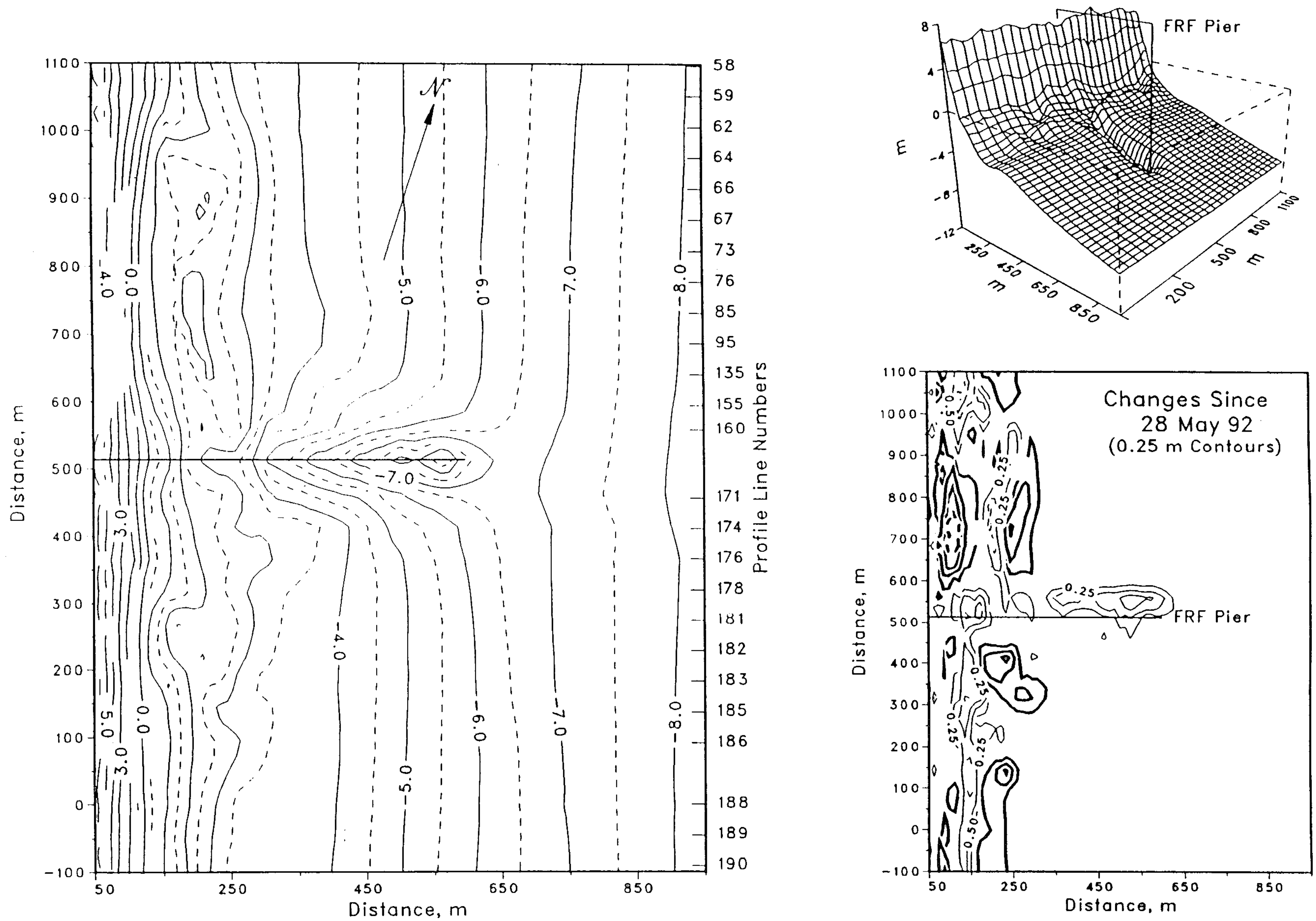


Figure A5. FRF Bathymetry, 25 June 92 (depths relative to NGVD)

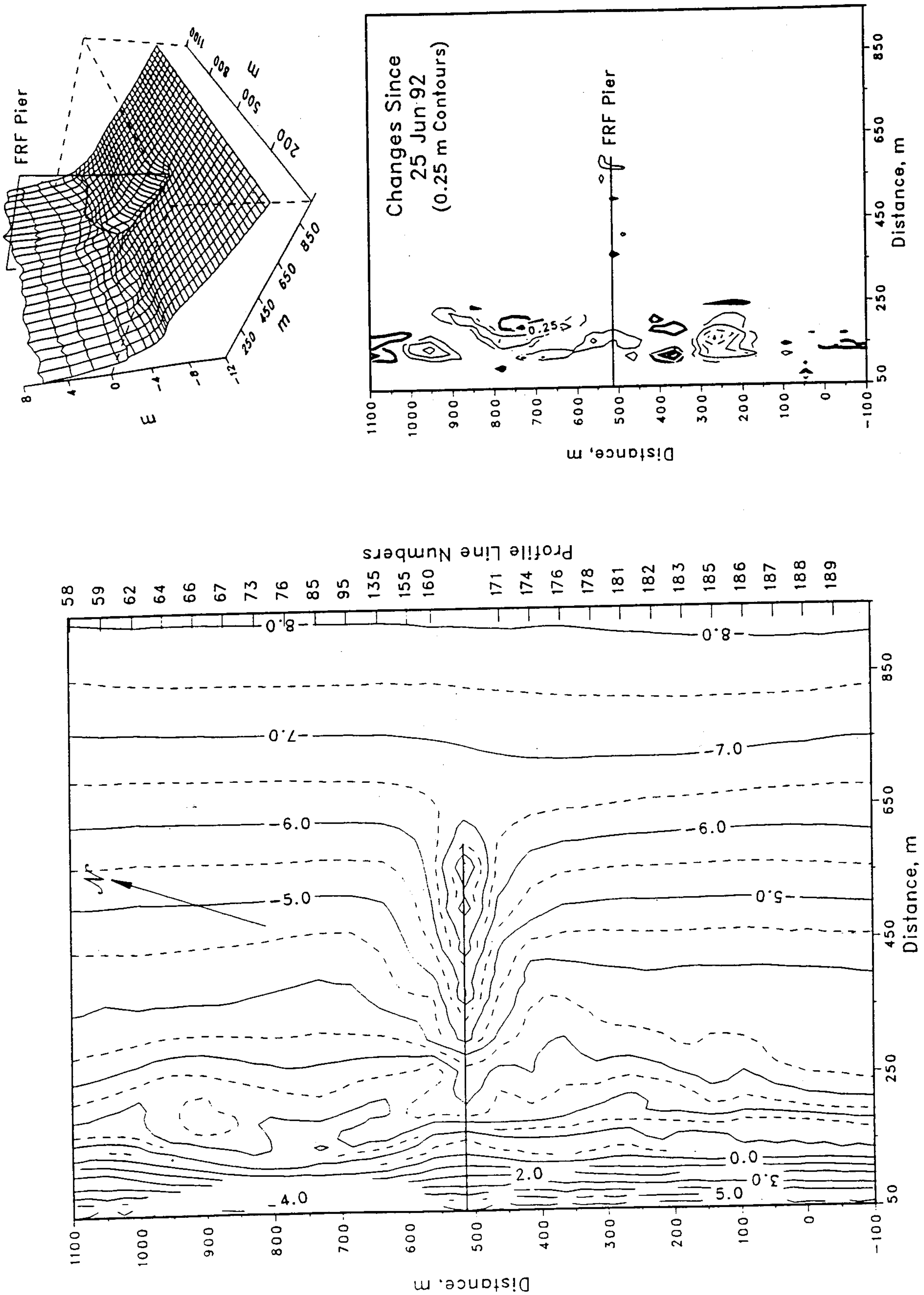


Figure A6. FRF Bathymetry, 10 August 92 (depths relative to NGVD)

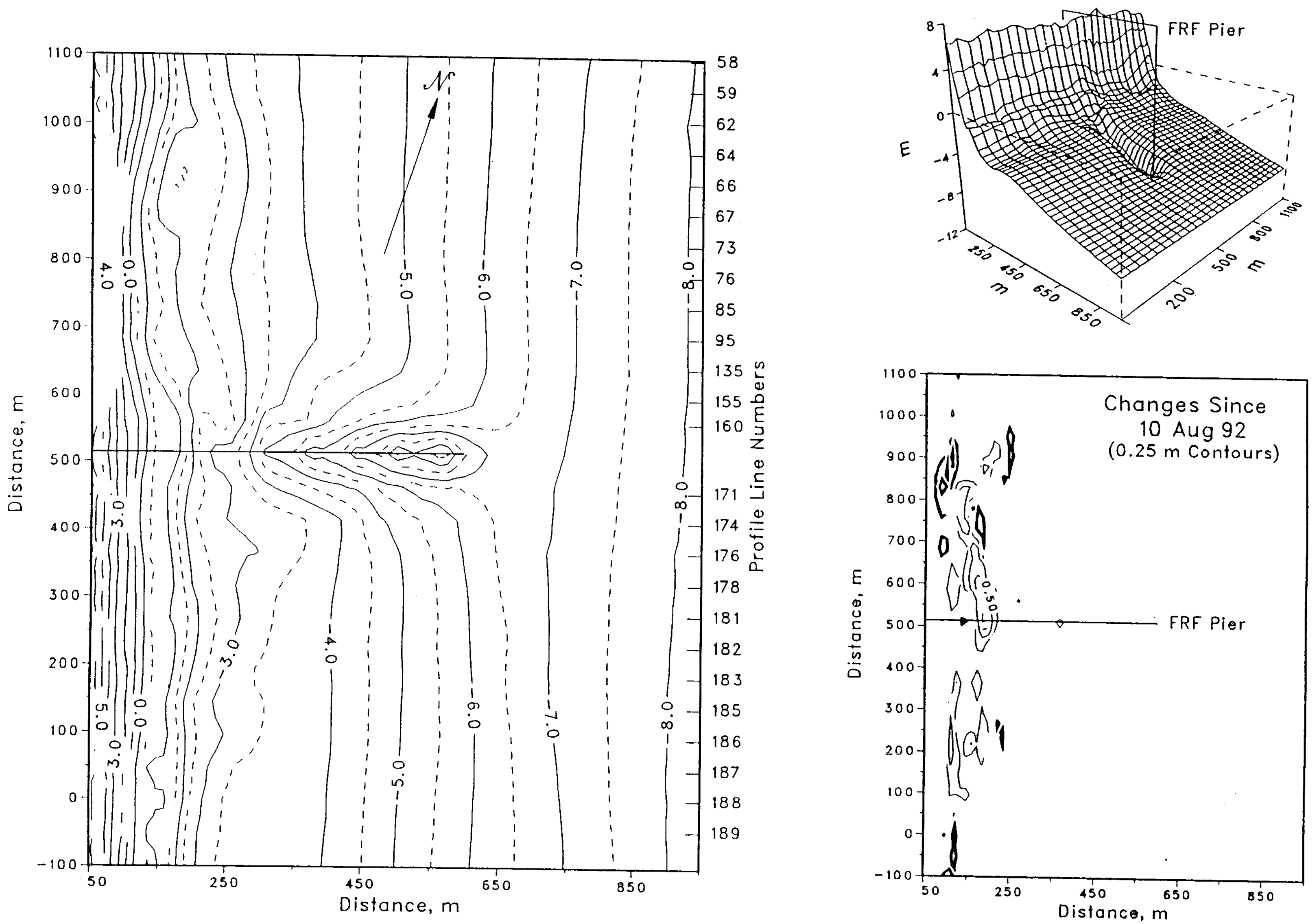


Figure A7. FRF Bathymetry, 2 September 92 (depths relative to NGVD)

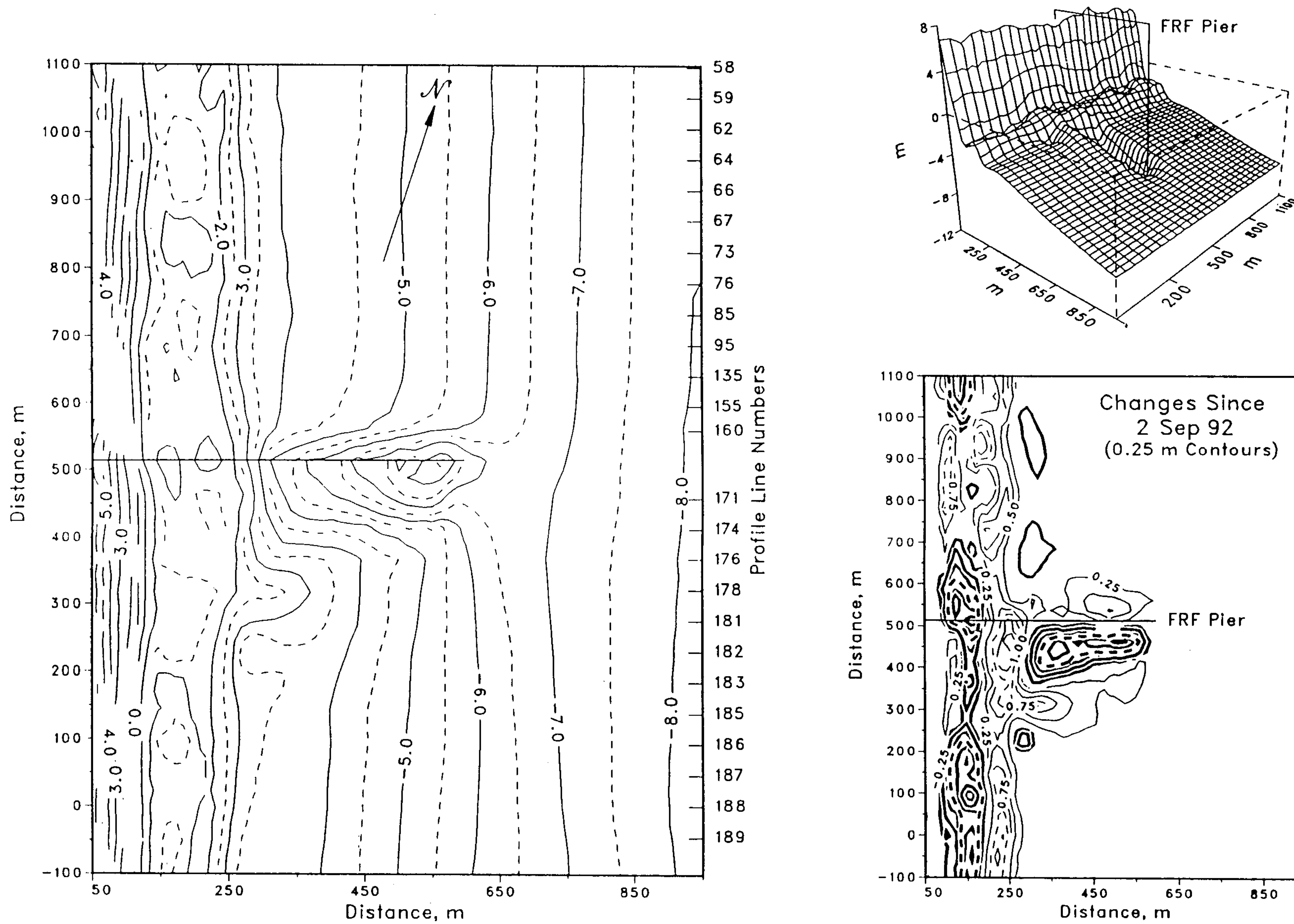


Figure A8. FRF Bathymetry, 26 October 92 (depths relative to NGVD)

Appendix B
Wave Data for Gage 630

Wave data summaries for Gage 630 for 1992 and for 1980 through 1992 are presented in the following pages:

Daily H_{mo} and T_p

Figure B1 displays the individual wave height H_{mo} and peak spectral wave period T_p values, along with the monthly mean values.

Joint Distributions of H_{mo} and T_p

Annual and monthly joint distribution tables are presented in Tables B1 and B2, and data for 1980 through 1992 are in Tables B3 and B4. Each table gives the frequency (in parts per 10,000) for which the wave height and peak period were within the specified intervals; these values can be converted to percentages by dividing by 100. Marginal totals are also included. The row total gives the number of observations out of 10,000 that fell within each specified peak period interval. The column total gives the number of observations out of 10,000 that fell within each specified wave height interval.

Cumulative Distributions of Wave Height

Annual and monthly wave height distributions for 1992 are plotted in cumulative form in Figures B2 and B3. Data for 1980 through 1992 are plotted in Figure B4.

Peak Spectral Wave Period Distributions

Annual and monthly peak wave period T_p distribution histograms for 1992 are presented in Figures B5 and B6. Data for 1980 through 1992 are presented in Figure B7.

Persistence of Wave Heights

Table B5 shows the number of times in 1992 when the specified wave height was equaled or exceeded at least once during each day for the duration (consecutive days). Data for 1980 through 1992 are averaged and given in Table B6. An example is shown below:

Height	Consecutive Day(s) or Longer																		
m	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19+
0.5	18	15		14	13	12		11	10	9				8		7			
1.0	50	34	24	21	18	14	12	8	7	3			2						
1.5	41	19	8	6	2	1													
2.0	22	9	5	1															
2.5	10	5	2																
3.0	6	1																	
3.5		1																	
4.0	1																		

This example indicates that wave heights equaled or exceeded 1.0 m 50 times for at least 1 day; 34 times for at least 2 days; 24 times for at least 3 days, etc. Therefore, on 16 occasions the height equaled or exceeded 1.0 m for 1 day exactly (50 - 34 = 16); on 10 occasions for 2 days; on 3 occasions for 3 days, etc. Note that the height exceeded 1 m 50 times for 1 day or longer, while heights exceeded 0.5 m only 18 times for this same duration. This change in durations occurred because the longer durations of lower waves may be interspersed with shorter, but more frequent, intervals of higher waves. For example, one of the times that the wave heights exceeded 0.5 m for 16 days may have represented three times the height exceeded 1 m for shorter durations.

Spectra

Monthly spectra for the offshore Waverider buoy (Gage 630) are presented in Figure B8. The plots show "relative" energy density as a function of wave frequency. These figures summarize the large number of spectra for each month. The figures emphasize the higher energy density associated with storms, as well as the general shifts in energy density to different frequencies. As used here, "relative" indicates the spectra have been smoothed by the three-dimensional surface drawing routine. Consequently, extremely high- and low-energy density values are modified to produce a smooth surface. The figures are not intended for quantitative measurements; however, they do provide the energy density as a function of frequency relative to the other spectra for the month.

Monthly and annual wave statistics for Gage 630 for 1992 and for 1980 through 1992 are presented in Table B7.

Figure B9 plots monthly time histories of wave height and period.

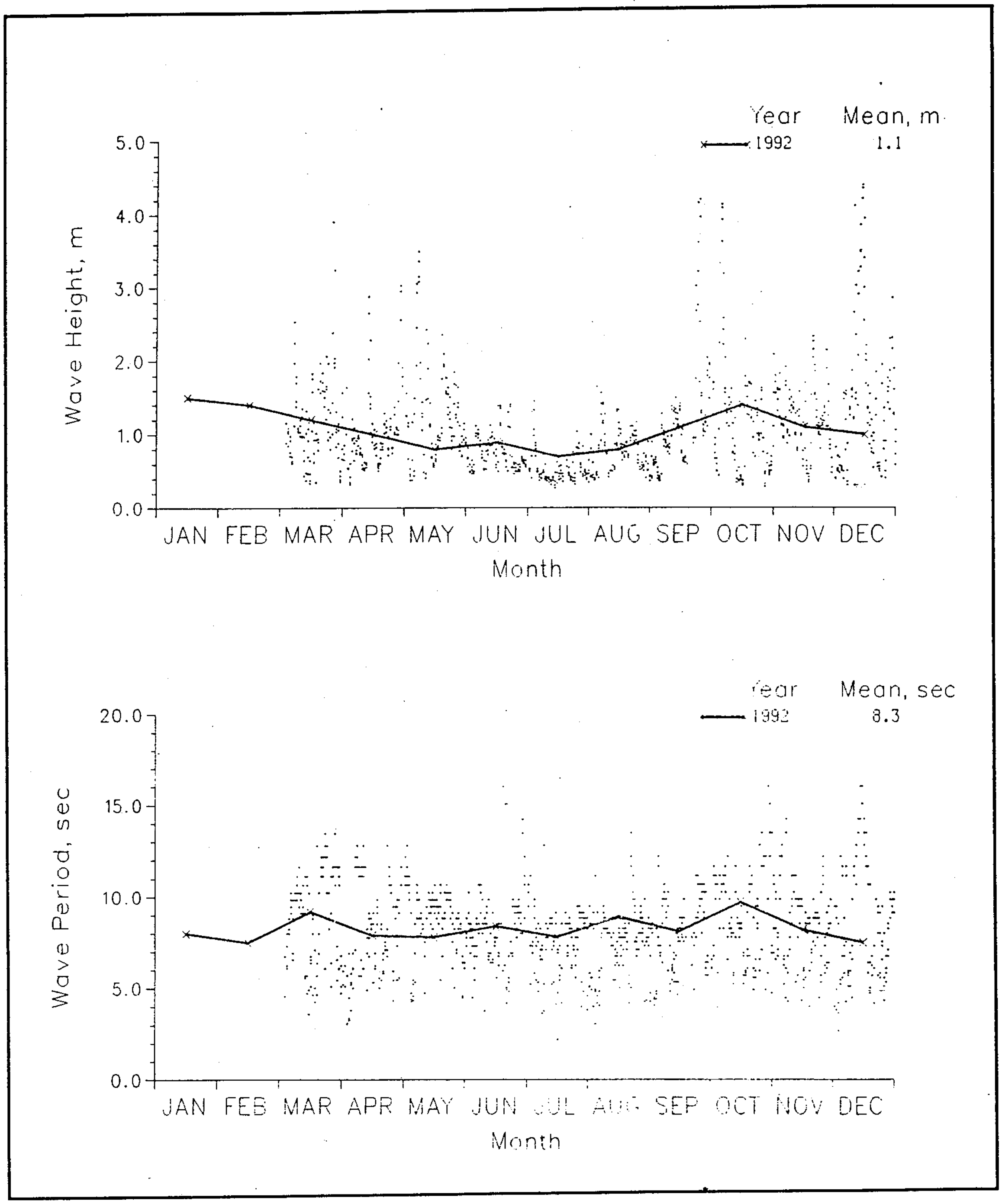


Figure B1. 1992 daily wave height and period values with monthly means for Gage 630

Table B1
Annual Joint Distribution of H_{mo} versus T_p

Annual 1992, Gage 630
Percent Occurrence(X100) of Height and Period

Height(m)	Period(sec)												Total
	2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-11.9	12.0-13.9	14.0-15.9	16.0-Longer	
0.00 - 0.49	9	26	70	88	79	254	474	184	175	.	53	.	1412
0.50 - 0.99	9	88	325	351	430	535	1026	728	500	61	193	.	4246
1.00 - 1.49	.	9	175	395	439	219	342	360	465	35	149	.	2588
1.50 - 1.99	.	.	26	211	307	53	105	96	211	18	35	.	1062
2.00 - 2.49	.	.	.	35	53	44	35	26	53	26	.	.	272
2.50 - 2.99	.	.	.	9	26	26	9	18	26	.	18	.	132
3.00 - 3.49	.	.	.	.	.	.	35	18	35	9	26	.	123
3.50 - 3.99	.	.	.	.	.	.	18	9	26	26	9	.	88
4.00 - 4.49	.	.	.	.	.	.	18	18	9	18	18	.	81
4.50 - 4.99	.	.	.	.	.	.	.	.	.	.	.	.	0
5.00 - Greater	.	.	.	.	.	.	.	.	.	.	.	.	0
Total	18	123	596	1089	1334	1131	2062	1457	1500	193	501	0	

Table B2
Monthly Joint Distribution of H_{mo} versus T_p

January 1992, Gage 630
Percent Occurrence(X100) of Height and Period

Gage Inoperative

Height(m)	Period(sec) 2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-11.9	12.0-13.9	14.0-15.9	16.0-Longer	Total
0.00 - 0.49	.	.	.	.	.	.	.	.	.	.	.	.	0
0.50 - 0.99	.	.	.	.	.	.	.	.	.	.	.	.	0
1.00 - 1.49	.	.	.	.	.	.	.	.	.	.	.	.	0
1.50 - 1.99	.	.	.	.	.	.	.	.	.	.	.	.	0
2.00 - 2.49	.	.	.	.				.	.	.	.	.	0
2.50 - 2.99	.	.	.	.	.	.	.	.	.	.	.	.	0
3.00 - 3.49	.	.	.	.	.	.	.	.	.	.	.	.	0
3.50 - 3.99	.	.	.	.	.	.	.	.	.	.	.	.	0
4.00 - 4.49	.	.	.	.	.	.	.	.	.	.	.	.	0
4.50 - 4.99	.	.	.	.	.	.	.	.	.	.	.	.	0
5.00 - Greater	.	.	.	.	.	.	.	.	.	.	.	.	0
Total	0	0	0	0	0	0	0	0	0	0	0	0	

February 1992, Gage 630
Percent Occurrence(X100) of Height and Period

Gage Inoperative

Height(m)	Period(sec) 2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-11.9	12.0-13.9	14.0-15.9	16.0-Longer	Total
0.00 - 0.49	.	.	.	.	.	.	.	.	.	.	.	.	0
0.50 - 0.99	.	.	.	.	.	.	.	.	.	.	.	.	0
1.00 - 1.49	.	.	.	.	.	.	.	.	.	.	.	.	0
1.50 - 1.99	.	.	.	.	.	.	.	.	.	.	.	.	0
2.00 - 2.49	.	.	.	.				.	.	.	.	.	0
2.50 - 2.99	.	.	.	.	.	.	.	.	.	.	.	.	0
3.00 - 3.49	.	.	.	.	.	.	.	.	.	.	.	.	0
3.50 - 3.99	.	.	.	.	.	.	.	.	.	.	.	.	0
4.00 - 4.49	.	.	.	.	.	.	.	.	.	.	.	.	0
4.50 - 4.99	.	.	.	.	.	.	.	.	.	.	.	.	0
5.00 - Greater	.	.	.	.	.	.	.	.	.	.	.	.	0
Total	0	0	0	0	0	0	0	0	0	0	0	0	

March 1992, Gage 630
Percent Occurrence(X100) of Height and Period

Height(m)	Period(sec) 2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-11.9	12.0-13.9	14.0-15.9	16.0-Longer	Total
0.00 - 0.49	.	91	.	.	.	91	.	273	545	.	.	.	1000
0.50 - 0.99	.	.	364	182	455	91	727	545	909	.	91	.	3364
1.00 - 1.49	.	.	182	455	545	91	91	364	909	91	364	.	3092
1.50 - 1.99	.	.	91	182	273	.	182	91	727	91	273	.	1910
2.00 - 2.49	.	.	.	.	91	.	.	182	91	.	.	.	364
2.50 - 2.99	.	.	.	.	91	.	.	.	.	.	.	.	91
3.00 - 3.49	.	.	.	.	.	.	.	.	91	.	.	.	91
3.50 - 3.99	.	.	.	.	.	.	.	.	91	.	.	.	91
4.00 - 4.49	.	.	.	.	.	.	.	.	.	.	.	.	0
4.50 - 4.99	.	.	.	.	.	.	.	.	.	.	.	.	0
5.00 - Greater	.	.	.	.	.	.	.	.	.	.	.	.	0
Total	0	91	637	819	1455	273	1000	1455	3363	182	728	0	

(Continued)

(Sheet 1 of 4)

Table B2 (Continued)

April 1992, Gage 630
Percent Occurrence(X100) of Height and Period

Height(m)	2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-11.9	12.0-13.9	14.0-15.9	16.0-Longer	Total
	Period(sec)												
0.00 - 0.49	.	92	92	.	92	.	.	.	.	.	.	.	276
0.50 - 0.99	.	275	.	1193	826	183	826	367	1376	.	642	.	5688
1.00 - 1.49	.	.	92	550	367	459	459	459	367	.	.	.	2753
1.50 - 1.99	.	.	92	183	92	.	.	.	275	.	.	.	642
2.00 - 2.49	.	.	.	.	.	183	.	.	.	.	.	.	183
2.50 - 2.99	.	.	.	92	92	.	92	92	.	.	.	.	368
3.00 - 3.49	.	.	.	.	.	.	.	92	.	.	.	.	92
3.50 - 3.99	.	.	.	.	.	.	.	.	.	.	.	.	0
4.00 - 4.49	.	.	.	.	.	.	.	.	.	.	.	.	0
4.50 - 4.99	.	.	.	.	.	.	.	.	.	.	.	.	0
5.00 - Greater	.	.	.	.	.	.	.	.	.	.	.	.	0
Total	0	367	276	2018	1469	825	1377	1010	2018	0	642	0	

May 1992, Gage 630
Percent Occurrence(X100) of Height and Period

Height(m)	2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-11.9	12.0-13.9	14.0-15.9	16.0-Longer	Total
	Period(sec)												
0.00 - 0.49	.	.	.	88	.	175	88	175	175	.	.	.	701
0.50 - 0.99	.	.	351	.	351	.	1053	1491	439	.	.	.	3685
1.00 - 1.49	.	.	351	88	263	88	702	526	789	.	175	.	2982
1.50 - 1.99	.	.	.	263	263	88	263	351	439	.	.	.	1667
2.00 - 2.49	.	.	.	.	175	88	88	88	.	.	.	.	439
2.50 - 2.99	.	.	.	.	88	.	.	.	.	.	.	.	88
3.00 - 3.49	.	.	.	.	.	.	175	88	88	.	.	.	351
3.50 - 3.99	.	.	.	.	.	.	.	.	88	.	.	.	88
4.00 - 4.49	.	.	.	.	.	.	.	.	.	.	.	.	0
4.50 - 4.99	.	.	.	.	.	.	.	.	.	.	.	.	0
5.00 - Greater	.	.	.	.	.	.	.	.	.	.	.	.	0
Total	0	0	702	439	1140	439	2369	2719	2018	0	175	0	

June 1992, Gage 630
Percent Occurrence(X100) of Height and Period

Height(m)	2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-11.9	12.0-13.9	14.0-15.9	16.0-Longer	Total
	Period(sec)												
0.00 - 0.49	.	.	.	.	.	87	174	87	87	.	.	.	435
0.50 - 0.99	.	87	87	174	1130	1217	2609	1391	435	174	696	.	8000
1.00 - 1.49	.	.	261	348	609	87	261	.	.	.	.	.	1566
1.50 - 1.99	.	.	.	.	.	.	.	.	.	.	.	.	0
2.00 - 2.49	.	.	.	.	.	.	.	.	.	.	.	.	0
2.50 - 2.99	.	.	.	.	.	.	.	.	.	.	.	.	0
3.00 - 3.49	.	.	.	.	.	.	.	.	.	.	.	.	0
3.50 - 3.99	.	.	.	.	.	.	.	.	.	.	.	.	0
4.00 - 4.49	.	.	.	.	.	.	.	.	.	.	.	.	0
4.50 - 4.99	.	.	.	.	.	.	.	.	.	.	.	.	0
5.00 - Greater	.	.	.	.	.	.	.	.	.	.	.	.	0
Total	0	87	348	522	1739	1391	3044	1478	522	174	696	0	

(Continued)

(Sheet 2 of 4)

Table B2 (Continued)

July 1992, Gage 630
Percent Occurrence(X100) of Height and Period

Height(m)	Period(sec) 2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-11.9	12.0-13.9	14.0-15.9	16.0-Longer	Total
0.00 - 0.49	88	.	175	439	526	1754	2456	351	88	.	175	.	6052
0.50 - 0.99	.	263	439	439	439	614	526	614	175	.	.	.	3509
1.00 - 1.49	.	.	.	88	175	88	88	.	.	.	.	.	439
1.50 - 1.99	.	.	.	.	.	.	.	.	.	.	.	.	0
2.00 - 2.49	.	.	.	.	.	.	.	.	.	.	.	.	0
2.50 - 2.99	.	.	.	.	.	.	.	.	.	.	.	.	0
3.00 - 3.49	.	.	.	.	.	.	.	.	.	.	.	.	0
3.50 - 3.99	.	.	.	.	.	.	.	.	.	.	.	.	0
4.00 - 4.49	.	.	.	.	.	.	.	.	.	.	.	.	0
4.50 - 4.99	.	.	.	.	.	.	.	.	.	.	.	.	0
5.00 - Greater	.	.	.	.	.	.	.	.	.	.	.	.	0
Total	88	263	614	966	1140	2456	3070	965	263	0	175	0	

August 1992, Gage 630
Percent Occurrence(X100) of Height and Period

Height(m)	Period(sec) 2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-11.9	12.0-13.9	14.0-15.9	16.0-Longer	Total
0.00 - 0.49	.	90	270	90	.	180	721	360	.	.	.	.	1711
0.50 - 0.99	.	90	541	360	631	2072	1622	450	180	90	.	.	6036
1.00 - 1.49	.	.	180	360	360	180	450	270	180	.	90	.	2070
1.50 - 1.99	.	.	.	90	.	.	.	.	90	.	.	.	180
2.00 - 2.49	.	.	.	.	.	.	.	.	.	.	.	.	0
2.50 - 2.99	.	.	.	.	.	.	.	.	.	.	.	.	0
3.00 - 3.49	.	.	.	.	.	.	.	.	.	.	.	.	0
3.50 - 3.99	.	.	.	.	.	.	.	.	.	.	.	.	0
4.00 - 4.49	.	.	.	.	.	.	.	.	.	.	.	.	0
4.50 - 4.99	.	.	.	.	.	.	.	.	.	.	.	.	0
5.00 - Greater	.	.	.	.	.	.	.	.	.	.	.	.	0
Total	0	180	991	900	991	2432	2793	1080	450	90	90	0	

September 1992, Gage 630
Percent Occurrence(X100) of Height and Period

Height(m)	Period(sec) 2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-11.9	12.0-13.9	14.0-15.9	16.0-Longer	Total
0.00 - 0.49	.	.	187	.	187	187	187	.	93	.	93	.	934
0.50 - 0.99	.	.	654	93	187	654	1308	841	374	.	.	.	4111
1.00 - 1.49	.	.	93	654	748	280	467	467	374	.	.	.	3083
1.50 - 1.99	.	.	93	187	374	.	.	93	187	.	.	.	934
2.00 - 2.49	.	.	.	93	.	.	.	.	.	.	.	.	93
2.50 - 2.99	.	.	.	.	.	187	.	.	93	.	.	.	280
3.00 - 3.49	.	.	.	.	.	.	187	.	.	.	.	.	187
3.50 - 3.99	.	.	.	.	.	.	93	93	.	.	.	.	186
4.00 - 4.49	.	.	.	.	.	.	93	.	93	.	.	.	186
4.50 - 4.99	.	.	.	.	.	.	.	.	.	.	.	.	0
5.00 - Greater	.	.	.	.	.	.	.	.	.	.	.	.	0
Total	0	0	1027	1027	1496	1308	2335	1494	1214	0	93	0	

(Continued)

(Sheet 3 of 4)

Table B2 (Concluded)

October 1992, Gage 630
Percent Occurrence(X100) of Height and Period

Height(m)	Period(sec) 2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-11.9	12.0-13.9	14.0-15.9	16.0-Longer	Total
0.00 - 0.49	.	.	.	83	.	83	667	83	500	.	250	.	1666
0.50 - 0.99	.	.	167	333	83	333	583	250	750	250	250	.	2999
1.00 - 1.49	.	83	167	500	333	.	250	333	667	167	333	.	2833
1.50 - 1.99	.	.	.	250	833	167	.	83	167	.	.	.	1500
2.00 - 2.49	.	.	.	167	.	83	83	.	167	.	.	.	500
2.50 - 2.99	.	.	.	.	.	.	.	.	83	.	.	.	83
3.00 - 3.49	.	.	.	.	.	.	.	.	83	.	.	.	83
3.50 - 3.99	.	.	.	.	.	.	83	.	83	.	.	.	166
4.00 - 4.49	.	.	.	.	.	.	83	83	.	.	.	.	166
4.50 - 4.99	.	.	.	.	.	.	.	.	.	.	.	.	0
5.00 - Greater	.	.	.	.	.	.	.	.	.	.	.	.	0
Total	0	83	334	1333	1249	666	1749	832	2500	417	833	0	

November 1992, Gage 630
Percent Occurrence(X100) of Height and Period

Height(m)	Period(sec) 2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-11.9	12.0-13.9	14.0-15.9	16.0-Longer	Total
0.00 - 0.49	.	.	.	.	.	.	333	250	.	.	.	.	583
0.50 - 0.99	.	.	167	167	.	.	833	667	167	83	167	.	2251
1.00 - 1.49	.	.	250	417	583	750	583	917	917	83	333	.	4833
1.50 - 1.99	.	.	.	417	583	167	417	167	167	.	.	.	1918
2.00 - 2.49	.	.	.	83	250	83	.	.	.	.	.	.	416
2.50 - 2.99	.	.	.	.	.	.	.	.	.	.	.	.	0
3.00 - 3.49	.	.	.	.	.	.	.	.	.	.	.	.	0
3.50 - 3.99	.	.	.	.	.	.	.	.	.	.	.	.	0
4.00 - 4.49	.	.	.	.	.	.	.	.	.	.	.	.	0
4.50 - 4.99	.	.	.	.	.	.	.	.	.	.	.	.	0
5.00 - Greater	.	.	.	.	.	.	.	.	.	.	.	.	0
Total	0	0	417	1084	1416	1000	2166	2001	1251	166	500	0	

December 1992, Gage 630
Percent Occurrence(X100) of Height and Period

Height(m)	Period(sec) 2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-11.9	12.0-13.9	14.0-15.9	16.0-Longer	Total
0.00 - 0.49	.	.	.	167	.	.	83	250	250	.	.	.	750
0.50 - 0.99	83	167	500	583	250	250	250	667	250	.	83	.	3083
1.00 - 1.49	.	.	167	500	417	167	83	250	417	.	167	.	2168
1.50 - 1.99	.	.	.	500	583	83	167	167	83	83	83	.	1749
2.00 - 2.49	.	.	.	.	.	.	167	.	250	250	.	.	667
2.50 - 2.99	.	.	.	.	.	83	.	83	83	.	167	.	416
3.00 - 3.49	.	.	.	.	.	.	.	.	83	83	250	.	416
3.50 - 3.99	.	.	.	.	.	.	.	.	.	250	83	.	333
4.00 - 4.49	.	.	.	.	.	.	.	83	.	167	167	.	417
4.50 - 4.99	.	.	.	.	.	.	.	.	.	.	.	.	0
5.00 - Greater	.	.	.	.	.	.	.	.	.	.	.	.	0
Total	83	167	667	1750	1250	583	750	1500	1416	833	1000	0	

(Sheet 4 of 4)

Table B3
Annual Joint Distribution of H_{mo} versus T_p (All Years)

Annual 1980-1992, Gage 630
Percent Occurrence(X100) of Height and Period

Height(m)	Period(sec)												Total
	2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-11.9	12.0-13.9	14.0-15.9	16.0-Longer	
0.00 - 0.49	26	15	29	62	86	124	342	272	189	61	121	4	1331
0.50 - 0.99	35	132	260	498	580	527	892	743	780	135	226	15	4823
1.00 - 1.49	.	9	146	405	425	249	288	222	332	40	123	3	2242
1.50 - 1.99	.	.	13	168	249	107	84	80	132	31	70	4	938
2.00 - 2.49	.	.	1	24	92	65	53	36	58	27	34	1	391
2.50 - 2.99	.	.	.	1	13	32	18	13	31	9	23	1	141
3.00 - 3.49	.	.	.	.	1	11	13	12	16	6	9	1	69
3.50 - 3.99	.	.	.	.	.	1	7	7	12	6	5	.	38
4.00 - 4.49	.	.	.	.	.	.	3	5	7	2	4	1	22
4.50 - 4.99	.	.	.	.	.	.	.	1	2	.	.	1	4
5.00 - Greater	.	.	.	.	.	.	1	.	1	1	1	1	5
Total	61	156	449	1158	1446	1116	1701	1391	1560	318	616	32	

Table B4
Monthly Joint Distribution of H_{mo} versus T_p (All Years)

January 1980-1992, Gage 630
Percent Occurrence(X100) of Height and Period

Height(m)	Period(sec) 2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-11.9	12.0-13.9	14.0-15.9	16.0-Longer	Total
0.00 - 0.49	88	8	8	80	72	40	151	247	215	48	96	.	1053
0.50 - 0.99	72	207	231	406	406	351	351	709	829	104	223	.	3889
1.00 - 1.49	.	16	159	598	534	247	207	199	486	24	56	8	2534
1.50 - 1.99	.	.	32	335	414	183	96	104	231	24	48	.	1467
2.00 - 2.49	.	.	.	32	175	183	96	32	104	32	24	8	686
2.50 - 2.99	.	.	.	.	16	64	64	16	64	16	40	.	280
3.00 - 3.49	.	.	.	.	.	16	24	8	32	.	.	.	80
3.50 - 3.99	.	.	.	.	.	.	.	.	.	.	.	.	0
4.00 - 4.49	.	.	.	.	.	.	.	.	8	.	.	.	8
4.50 - 4.99	.	.	.	.	.	.	.	.	8	.	.	.	8
5.00 - Greater	.	.	.	.	.	.	.	.	.	.	.	.	0
Total	160	231	430	1451	1617	1084	989	1315	1977	248	487	16	

February 1980-1992, Gage 630
Percent Occurrence(X100) of Height and Period

Height(m)	Period(sec) 2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-11.9	12.0-13.9	14.0-15.9	16.0-Longer	Total
0.00 - 0.49	9	.	9	44	61	44	87	79	79	26	105	.	543
0.50 - 0.99	52	96	175	419	471	314	497	689	1003	17	166	9	3908
1.00 - 1.49	.	9	131	646	620	253	305	332	532	70	201	.	3099
1.50 - 1.99	.	.	9	227	358	183	113	113	192	52	96	.	1343
2.00 - 2.49	.	.	.	79	166	44	35	79	79	44	96	.	622
2.50 - 2.99	.	.	.	9	17	52	17	9	96	17	61	9	287
3.00 - 3.49	.	.	.	.	.	17	9	26	26	17	17	.	112
3.50 - 3.99	.	.	.	.	.	.	.	9	9	.	9	.	27
4.00 - 4.49	.	.	.	.	.	.	.	9	35	.	9	.	53
4.50 - 4.99	.	.	.	.	.	.	.	.	.	.	.	.	0
5.00 - Greater	.	.	.	.	.	.	9	.	.	.	.	.	9
Total	61	105	324	1424	1693	907	1072	1345	2051	243	760	18	

March 1980-1992, Gage 630
Percent Occurrence(X100) of Height and Period

Height(m)	Period(sec) 2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-11.9	12.0-13.9	14.0-15.9	16.0-Longer	Total
0.00 - 0.49	7	7	7	14	34	41	95	48	157	61	109	.	580
0.50 - 0.99	7	68	184	416	422	375	620	688	899	109	211	.	3999
1.00 - 1.49	.	7	211	436	490	313	347	293	681	54	313	.	3145
1.50 - 1.99	.	.	14	238	266	102	109	150	279	68	116	.	1342
2.00 - 2.49	.	.	.	20	68	41	95	61	129	27	82	.	523
2.50 - 2.99	.	.	.	.	27	14	20	7	41	14	34	.	157
3.00 - 3.49	.	.	.	.	7	14	7	14	48	7	7	.	104
3.50 - 3.99	.	.	.	.	.	.	.	14	54	.	14	.	82
4.00 - 4.49	.	.	.	.	.	.	7	14	14	.	20	.	55
4.50 - 4.99	.	.	.	.	.	.	.	.	14	.	.	.	14
5.00 - Greater	.	.	.	.	.	.	.	.	.	.	.	.	0
Total	14	82	416	1124	1314	900	1300	1289	2316	340	906	0	

(Continued)

(Sheet 1 of 4)

Table B4 (Continued)

April 1980-1992, Gage 630
Percent Occurrence(X100) of Height and Period

Height(m)	Period(sec) 2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-11.9	12.0-13.9	14.0-15.9	16.0-Longer	Total
0.00 - 0.49	7	14	21	42	35	21	244	188	139	70	70	.	851
0.50 - 0.99	63	181	230	487	634	474	857	808	1093	202	397	.	5426
1.00 - 1.49	.	7	104	251	404	320	376	334	299	49	132	.	2276
1.50 - 1.99	.	.	7	160	153	84	97	97	174	21	77	.	870
2.00 - 2.49	.	.	.	35	56	21	42	56	42	21	7	.	280
2.50 - 2.99	.	.	.	7	14	21	35	21	28	21	14	.	161
3.00 - 3.49	.	.	.	.	.	28	14	28	21	.	.	.	91
3.50 - 3.99	.	.	.	.	.	7	28	.	.	.	.	.	35
4.00 - 4.49	.	.	.	.	.	.	7	.	.	.	.	.	7
4.50 - 4.99	.	.	.	.	.	.	.	7	.	.	.	.	7
5.00 - Greater	.	.	.	.	.	.	.	.	.	.	.	.	0
Total	70	202	362	982	1296	976	1700	1539	1796	384	697	0	

May 1980-1992, Gage 630
Percent Occurrence(X100) of Height and Period

Height(m)	Period(sec) 2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-11.9	12.0-13.9	14.0-15.9	16.0-Longer	Total
0.00 - 0.49	7	20	48	96	137	143	369	259	212	48	123	.	1462
0.50 - 0.99	20	177	375	587	567	819	1201	935	662	96	198	.	5637
1.00 - 1.49	.	7	150	232	328	198	396	239	307	14	82	.	1953
1.50 - 1.99	.	.	7	75	89	48	116	82	116	20	55	.	608
2.00 - 2.49	.	.	.	14	55	55	14	34	7	20	20	.	219
2.50 - 2.99	.	.	.	.	27	7	7	7	7	14	7	.	76
3.00 - 3.49	.	.	.	.	.	.	14	7	7	7	7	.	42
3.50 - 3.99	.	.	.	.	.	.	.	.	7	.	.	.	7
4.00 - 4.49	.	.	.	.	.	.	.	.	.	.	.	.	0
4.50 - 4.99	.	.	.	.	.	.	.	.	.	.	.	.	0
5.00 - Greater	.	.	.	.	.	.	.	.	.	.	.	.	0
Total	27	204	580	1004	1203	1270	2117	1563	1325	219	492	0	

June 1980-1992, Gage 630
Percent Occurrence(X100) of Height and Period

Height(m)	Period(sec) 2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-11.9	12.0-13.9	14.0-15.9	16.0-Longer	Total
0.00 - 0.49	22	29	44	118	184	324	662	508	199	37	29	.	2156
0.50 - 0.99	44	206	331	611	758	728	1751	1023	515	132	103	.	6202
1.00 - 1.49	.	7	103	235	213	169	206	96	88	.	37	.	1154
1.50 - 1.99	.	.	15	52	96	52	29	15	88	.	44	.	391
2.00 - 2.49	.	.	.	.	22	15	44	7	.	.	.	.	88
2.50 - 2.99	.	.	.	.	.	7	.	.	.	.	.	.	7
3.00 - 3.49	.	.	.	.	.	.	.	.	.	.	.	.	0
3.50 - 3.99	.	.	.	.	.	.	.	.	.	.	.	.	0
4.00 - 4.49	.	.	.	.	.	.	.	.	.	.	.	.	0
4.50 - 4.99	.	.	.	.	.	.	.	.	.	.	.	.	0
5.00 - Greater	.	.	.	.	.	.	.	.	.	.	.	.	0
Total	66	242	493	1016	1273	1295	2692	1649	890	169	213	0	

(Continued)

(Sheet 2 of 4)

Table B4 (Continued)

July 1980-1992, Gage 630
Percent Occurrence(X100) of Height and Period

Height(m)	2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-11.9	12.0-13.9	14.0-15.9	16.0-Longer	Total
0.00 - 0.49	14	14	57	115	230	438	1126	653	251	86	194	14	3192
0.50 - 0.99	29	158	344	681	868	789	1392	875	387	194	115	57	5889
1.00 - 1.49	.	14	57	187	222	86	122	36	36	.	.	.	760
1.50 - 1.99	.	.	.	43	7	14	22	14	36	.	.	.	136
2.00 - 2.49	.	.	.	7	.	.	7	.	.	.	.	.	14
2.50 - 2.99	.	.	.	.	.	.	.	.	.	.	.	.	0
3.00 - 3.49	.	.	.	.	.	.	.	.	.	.	.	.	0
3.50 - 3.99	.	.	.	.	.	.	.	.	.	.	.	.	0
4.00 - 4.49	.	.	.	.	.	.	.	.	.	.	.	.	0
4.50 - 4.99	.	.	.	.	.	.	.	.	.	.	.	.	0
5.00 - Greater	.	.	.	.	.	.	.	.	.	.	.	.	0
Total	43	186	458	1033	1327	1327	2669	1578	710	280	309	71	

August 1980-1992, Gage 630
Percent Occurrence(X100) of Height and Period

Height(m)	2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-11.9	12.0-13.9	14.0-15.9	16.0-Longer	Total
0.00 - 0.49	21	28	71	106	134	191	594	495	325	71	92	.	2128
0.50 - 0.99	35	92	255	537	827	806	1294	835	771	149	290	35	5926
1.00 - 1.49	.	7	134	311	269	184	240	134	92	14	35	.	1420
1.50 - 1.99	.	.	.	71	127	50	28	14	21	.	28	.	339
2.00 - 2.49	.	.	.	14	28	14	14	.	28	7	7	.	112
2.50 - 2.99	.	.	.	.	7	.	14	.	7	.	7	.	35
3.00 - 3.49	.	.	.	.	7	7	7	.	7	.	.	.	28
3.50 - 3.99	.	.	.	.	.	.	.	7	.	.	.	.	7
4.00 - 4.49	.	.	.	.	.	.	.	.	.	.	.	.	0
4.50 - 4.99	.	.	.	.	.	.	.	.	.	.	.	.	0
5.00 - Greater	.	.	.	.	.	.	.	.	.	.	.	.	0
Total	56	127	460	1039	1399	1252	2191	1485	1251	241	459	35	

September 1980-1992, Gage 630
Percent Occurrence(X100) of Height and Period

Height(m)	2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-11.9	12.0-13.9	14.0-15.9	16.0-Longer	Total
0.00 - 0.49	7	7	21	28	35	28	113	226	205	85	85	7	847
0.50 - 0.99	.	99	212	381	508	593	924	783	953	134	261	.	4848
1.00 - 1.49	.	7	85	480	487	311	494	254	332	85	148	7	2690
1.50 - 1.99	.	.	14	141	289	134	85	113	71	21	99	7	974
2.00 - 2.49	.	.	.	35	85	49	71	21	56	56	56	.	429
2.50 - 2.99	.	.	.	.	.	56	21	7	7	7	7	.	105
3.00 - 3.49	.	.	.	.	.	7	14	7	7	7	7	.	49
3.50 - 3.99	.	.	.	.	.	.	7	7	7	7	7	.	35
4.00 - 4.49	.	.	.	.	.	.	7	.	7	.	.	.	14
4.50 - 4.99	.	.	.	.	.	.	.	.	.	.	.	.	0
5.00 - Greater	.	.	.	.	.	.	.	.	.	7	.	.	7
Total	7	113	332	1065	1404	1178	1736	1418	1645	409	670	21	

(Continued)

(Sheet 3 of 4)

Table B4 (Concluded)

October 1980-1992, Gage 630
Percent Occurrence(X100) of Height and Period

Height(m)	2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-11.9	12.0-13.9	14.0-15.9	16.0-Longer	Total
0.00 - 0.49	27	.	.	7	41	74	209	122	223	27	128	.	858
0.50 - 0.99	27	54	169	351	358	317	675	486	912	182	344	7	3882
1.00 - 1.49	.	7	169	581	358	182	223	290	432	88	203	.	2533
1.50 - 1.99	.	.	27	236	412	128	81	101	169	95	189	27	1465
2.00 - 2.49	.	.	.	34	108	155	68	74	142	41	61	7	690
2.50 - 2.99	.	.	.	.	34	88	27	54	47	20	61	.	331
3.00 - 3.49	.	.	.	.	.	27	7	7	20	14	34	7	116
3.50 - 3.99	.	.	.	.	.	.	14	20	7	20	7	.	68
4.00 - 4.49	.	.	.	.	.	.	14	14	14	.	.	7	49
4.50 - 4.99	.	.	.	.	.	.	.	.	.	.	.	7	7
5.00 - Greater	.	.	.	.	.	.	.	.	.	.	.	7	7
Total	54	61	365	1209	1311	971	1318	1168	1966	487	1027	69	

November 1980-1992, Gage 630
Percent Occurrence(X100) of Height and Period

Height(m)	2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-11.9	12.0-13.9	14.0-15.9	16.0-Longer	Total
0.00 - 0.49	39	31	24	24	39	94	282	196	86	55	180	24	1074
0.50 - 0.99	39	78	345	596	518	431	541	549	565	118	125	39	3944
1.00 - 1.49	.	16	259	502	675	431	306	314	329	47	125	24	3028
1.50 - 1.99	.	.	16	227	353	196	149	78	110	47	8	8	1192
2.00 - 2.49	.	.	.	31	133	118	102	31	24	16	8	.	463
2.50 - 2.99	.	.	.	.	8	31	8	16	39	.	16	.	118
3.00 - 3.49	.	.	.	.	.	8	16	39	.	8	8	.	79
3.50 - 3.99	.	.	.	.	.	.	8	8	31	16	8	.	71
4.00 - 4.49	.	.	.	.	.	.	.	8	8	8	.	.	24
4.50 - 4.99	.	.	.	.	.	.	.	8	.	.	.	.	8
5.00 - Greater	.	.	.	.	.	.	.	.	.	.	.	.	0
Total	78	125	644	1380	1726	1309	1412	1247	1192	315	478	95	

December 1980-1992, Gage 630
Percent Occurrence(X100) of Height and Period

Height(m)	2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-11.9	12.0-13.9	14.0-15.9	16.0-Longer	Total
0.00 - 0.49	73	24	41	73	16	24	106	220	138	122	252	8	1097
0.50 - 0.99	41	179	269	497	611	236	423	489	774	155	252	33	3959
1.00 - 1.49	.	.	195	472	586	309	212	147	407	33	138	.	2499
1.50 - 1.99	.	.	24	244	497	138	98	73	98	16	65	.	1253
2.00 - 2.49	.	.	16	.	252	106	49	41	90	65	49	.	668
2.50 - 2.99	.	.	.	.	.	49	.	24	57	.	41	.	171
3.00 - 3.49	.	.	.	.	.	8	57	16	24	8	33	.	146
3.50 - 3.99	.	.	.	.	.	.	24	16	24	24	16	.	104
4.00 - 4.49	.	.	.	.	.	.	.	16	8	24	24	.	72
4.50 - 4.99	.	.	.	.	.	.	.	.	.	.	.	.	0
5.00 - Greater	.	.	.	.	.	.	.	.	8	8	8	.	24
Total	114	203	545	1286	1962	870	969	1042	1628	455	878	41	

(Sheet 4 of 4)

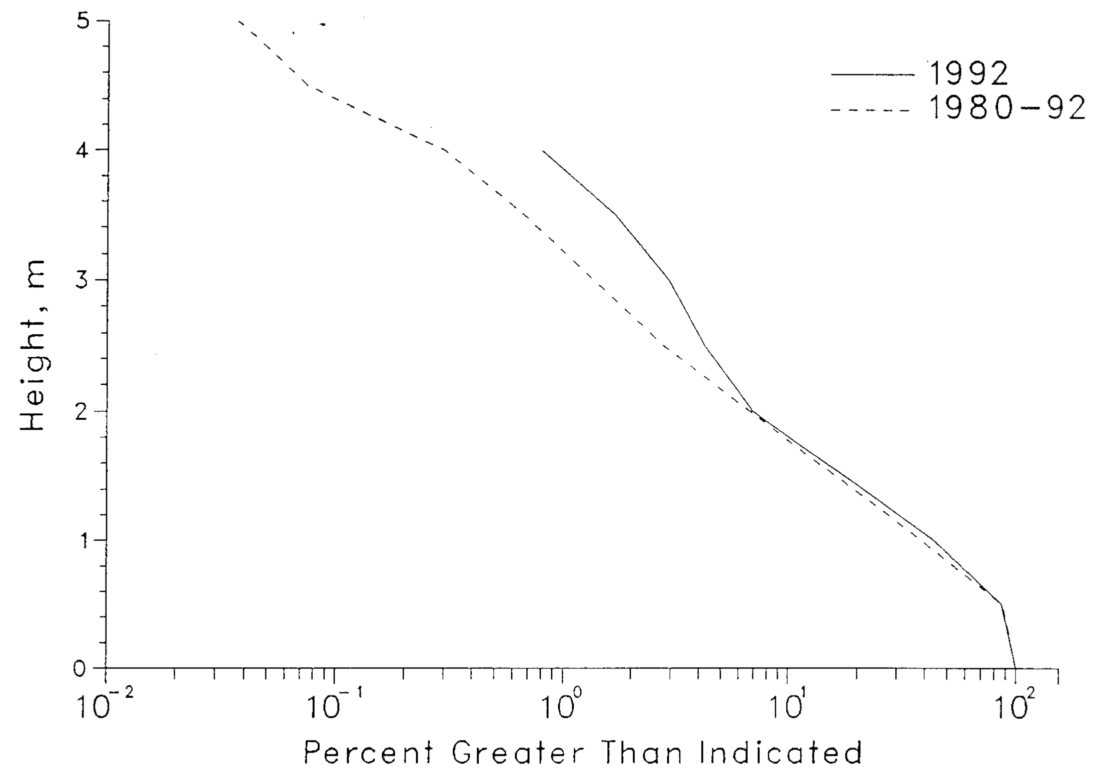


Figure B2. Annual cumulative wave height distributions for Gage 630

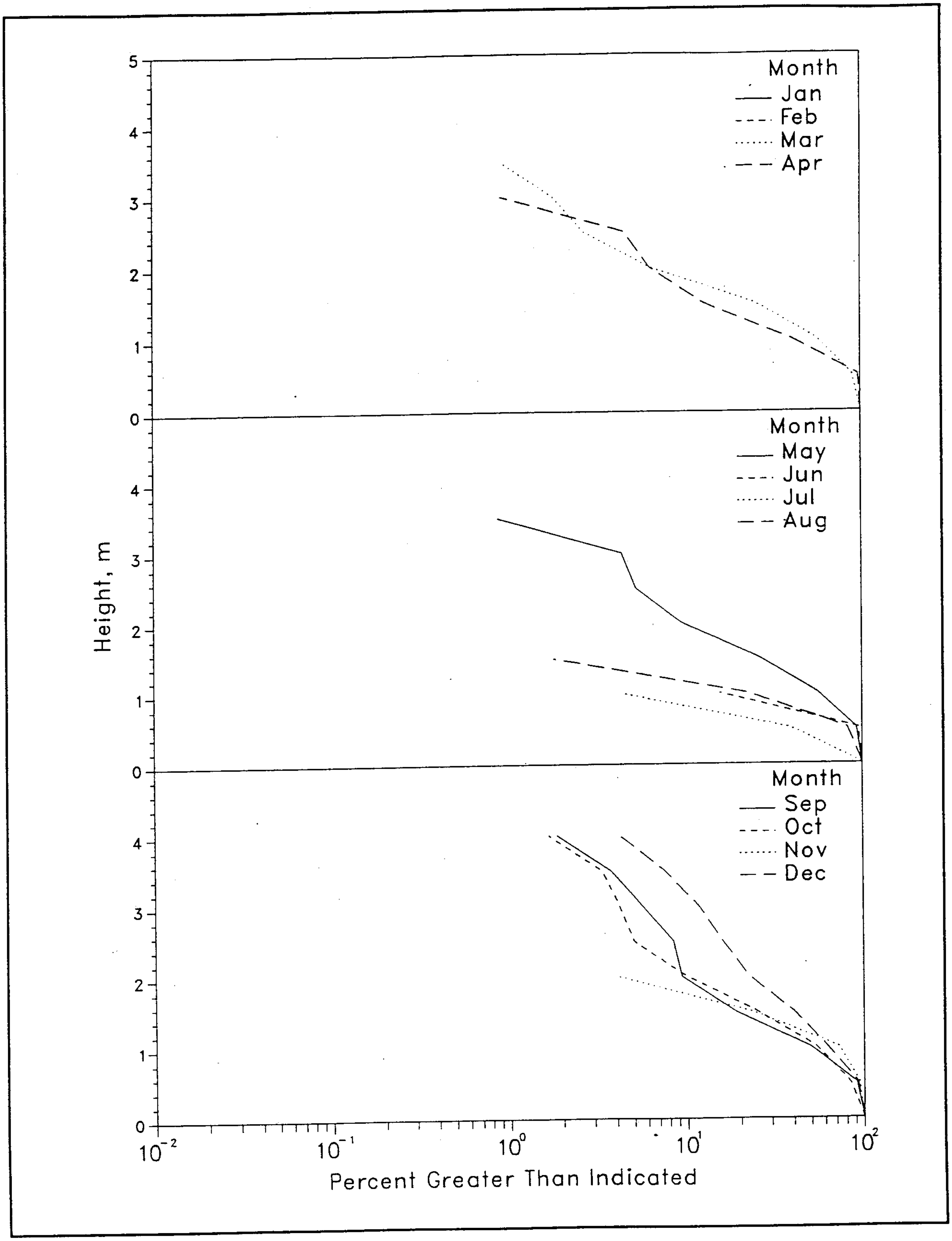


Figure B3. 1992 monthly wave height distributions for Gage 630

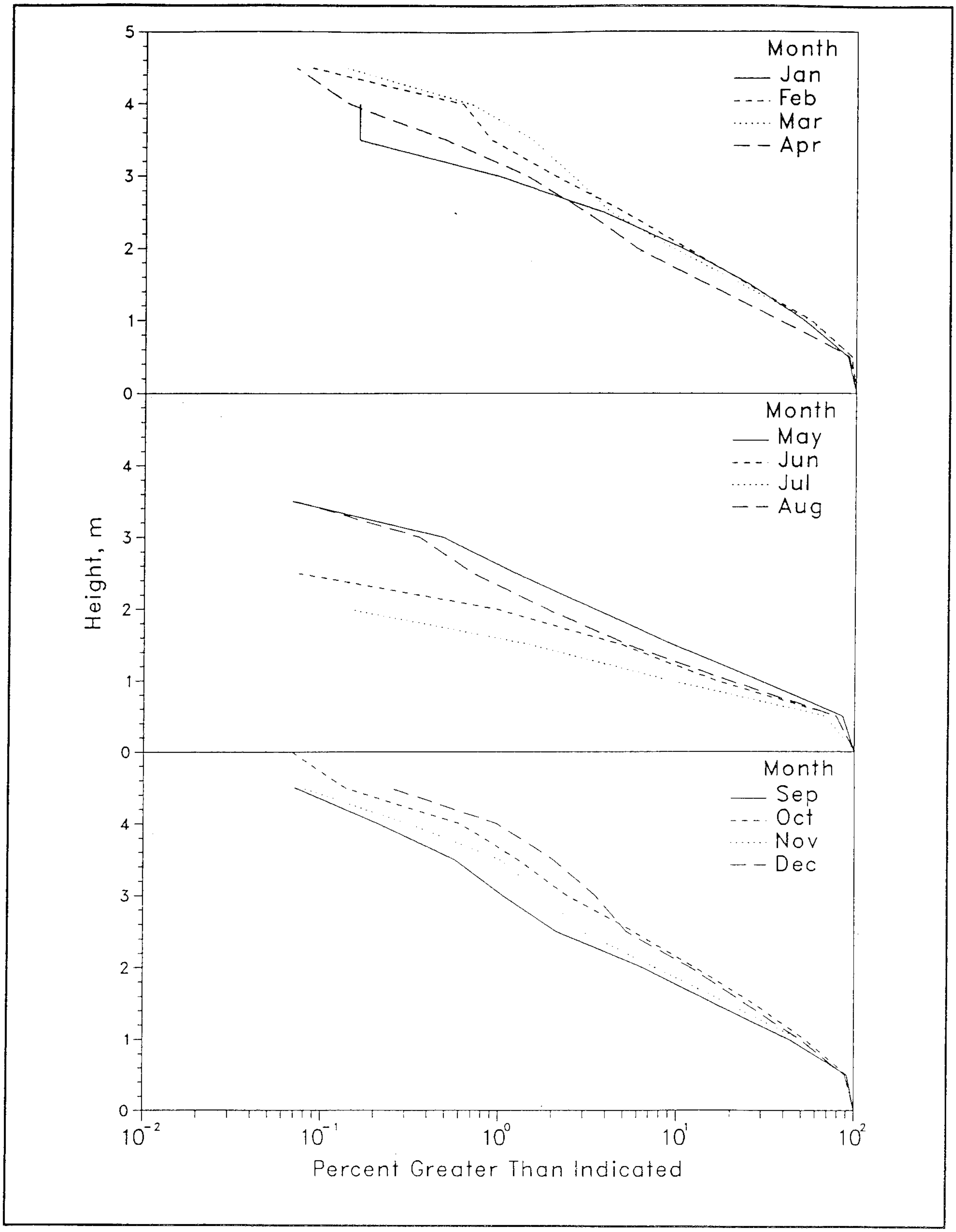


Figure B4. 1980-1992 monthly wave height distributions for Gage 630

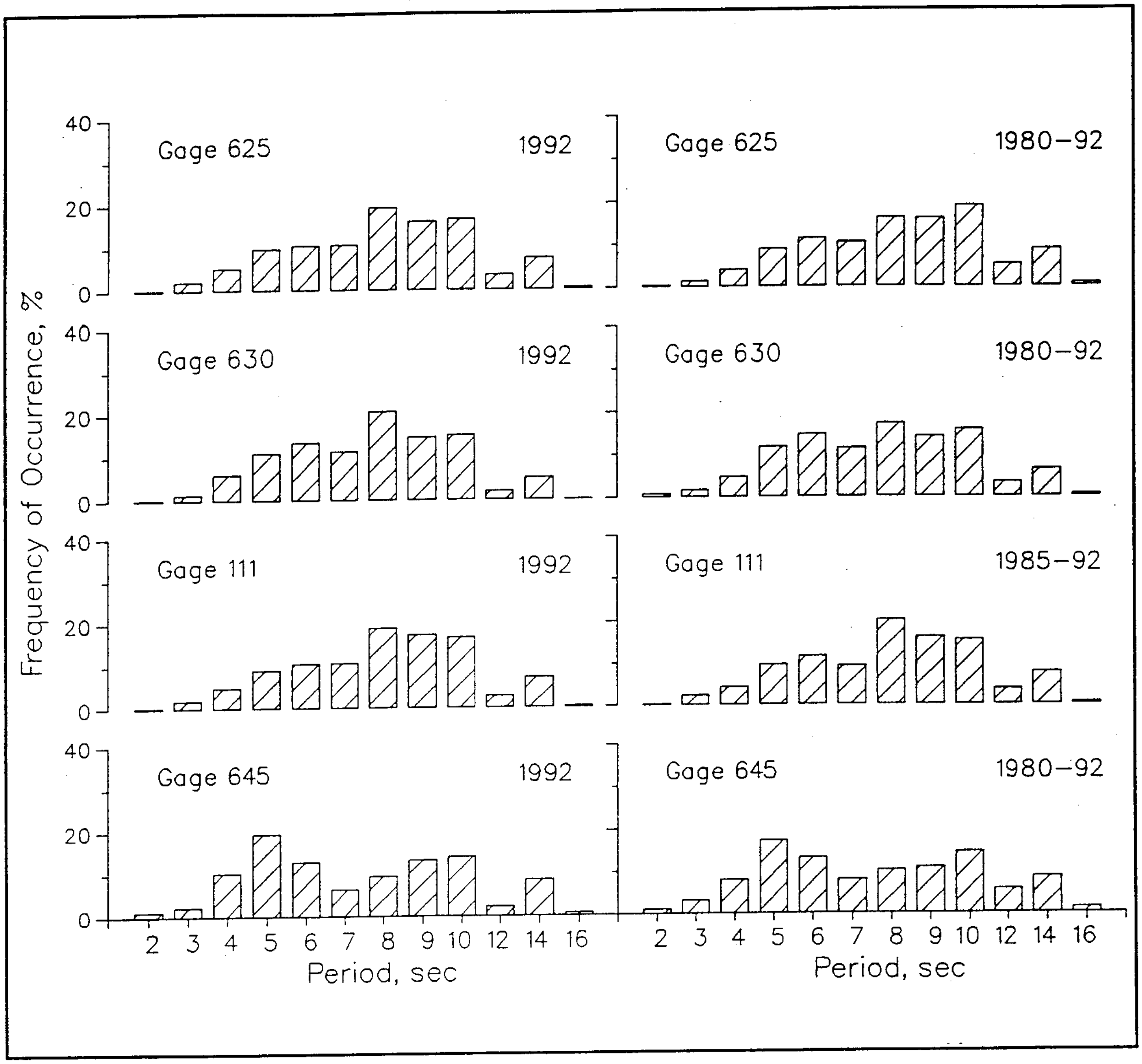


Figure B5. Annual wave period distributions for all gages

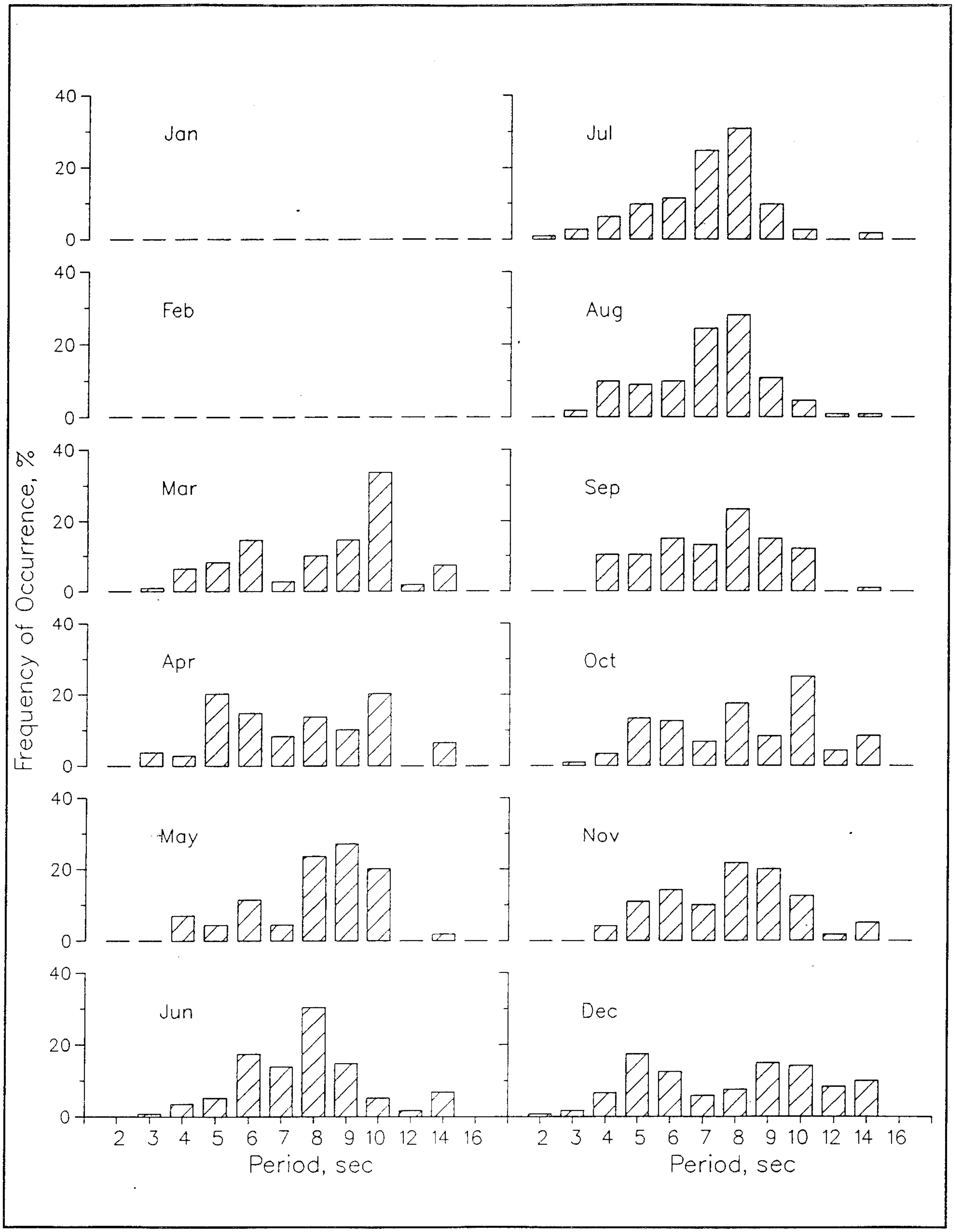


Figure B6. 1992 monthly wave period distributions for Gage 630

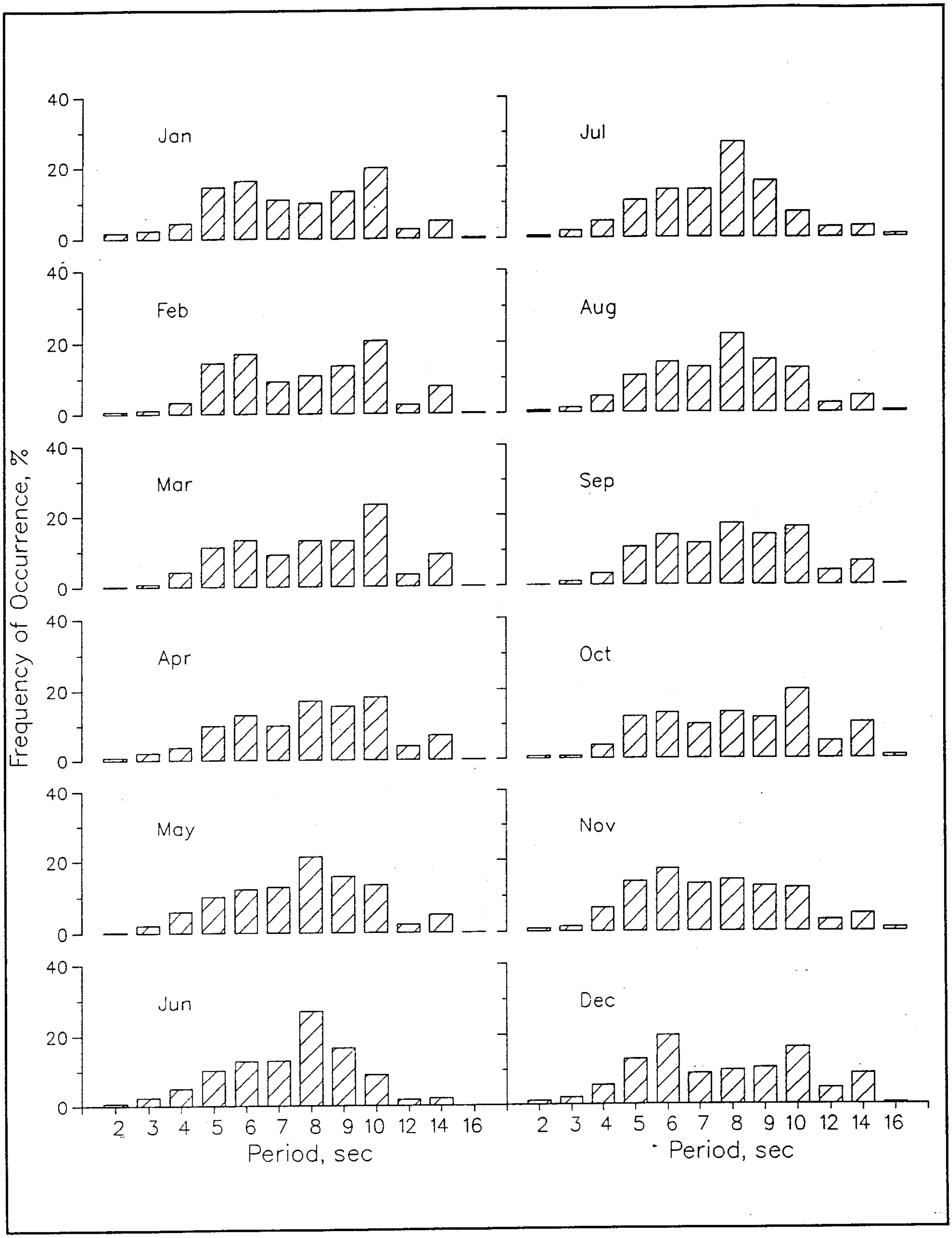


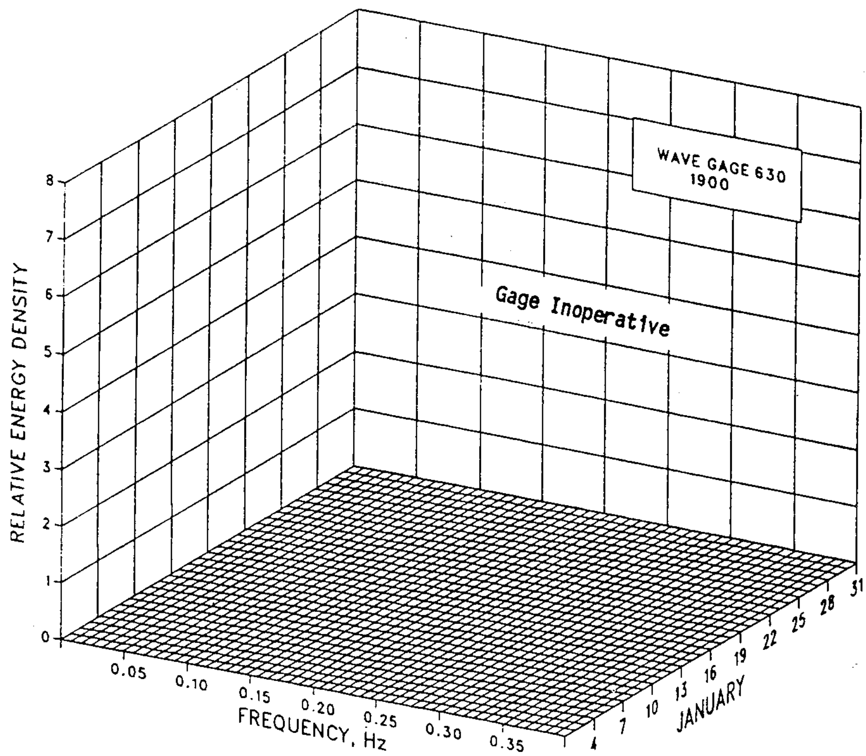
Figure B7. 1980-1992 monthly wave period distributions for Gage 630

Table B5
1992 persistence of H_{mo} for Gage 630

Height	Consecutive Day(s) or Longer																	
(m)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19+
0.5	21	20	15	13	12	10	9			8									6
1.0	50	39	22	19	15	13	11	10	9	7	4		3			2	1		
1.5	43	24	16	11	3				2	1									
2.0	19	11	6			2	1												
2.5	11	7			3	1													
3.0	8	6			2	1													
3.5	3	3	1																
4.0	5	1																	

Table B6
1980 through 1992 persistence of H_{mo} for Gage 630

Height	Consecutive Day(s) or Longer																		
(m)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19+
0.5	20	18	16	15	14	13	12	11		10	9		8	7	6	5			4
1.0	50	35	24	17	14	10	8	6	5	4	3		2				1		
1.5	39	22	11	6	4	2			1										
2.0	22	11	4	2		1													
2.5	11	5	2	1															
3.0	6	2	1																
3.5	3	1																	
4.0	2	1																	



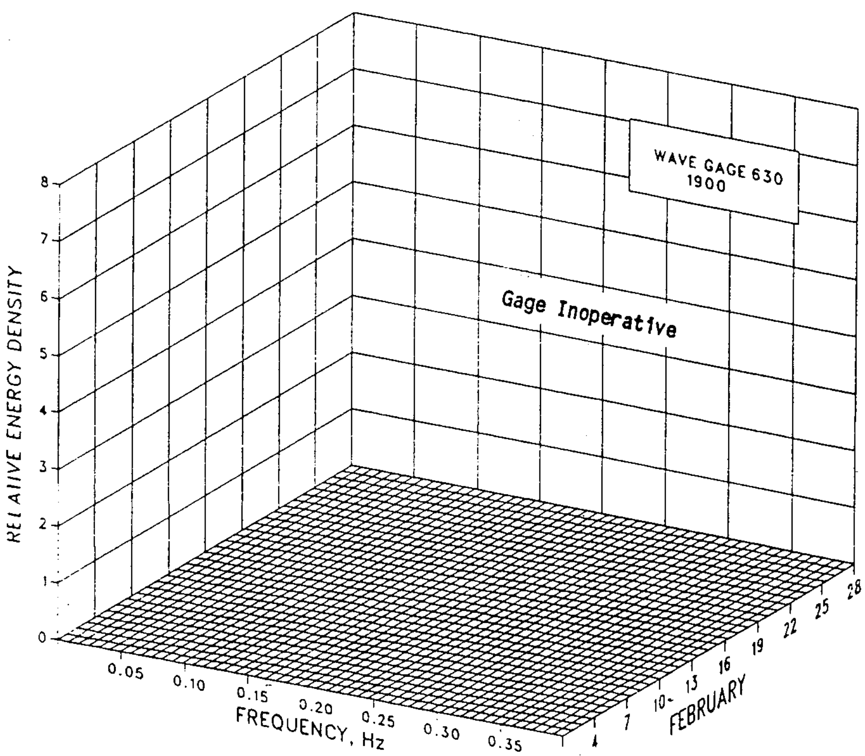


Figure B8. 1992 monthly spectra for Gage 630 (Sheet 1 of 6)

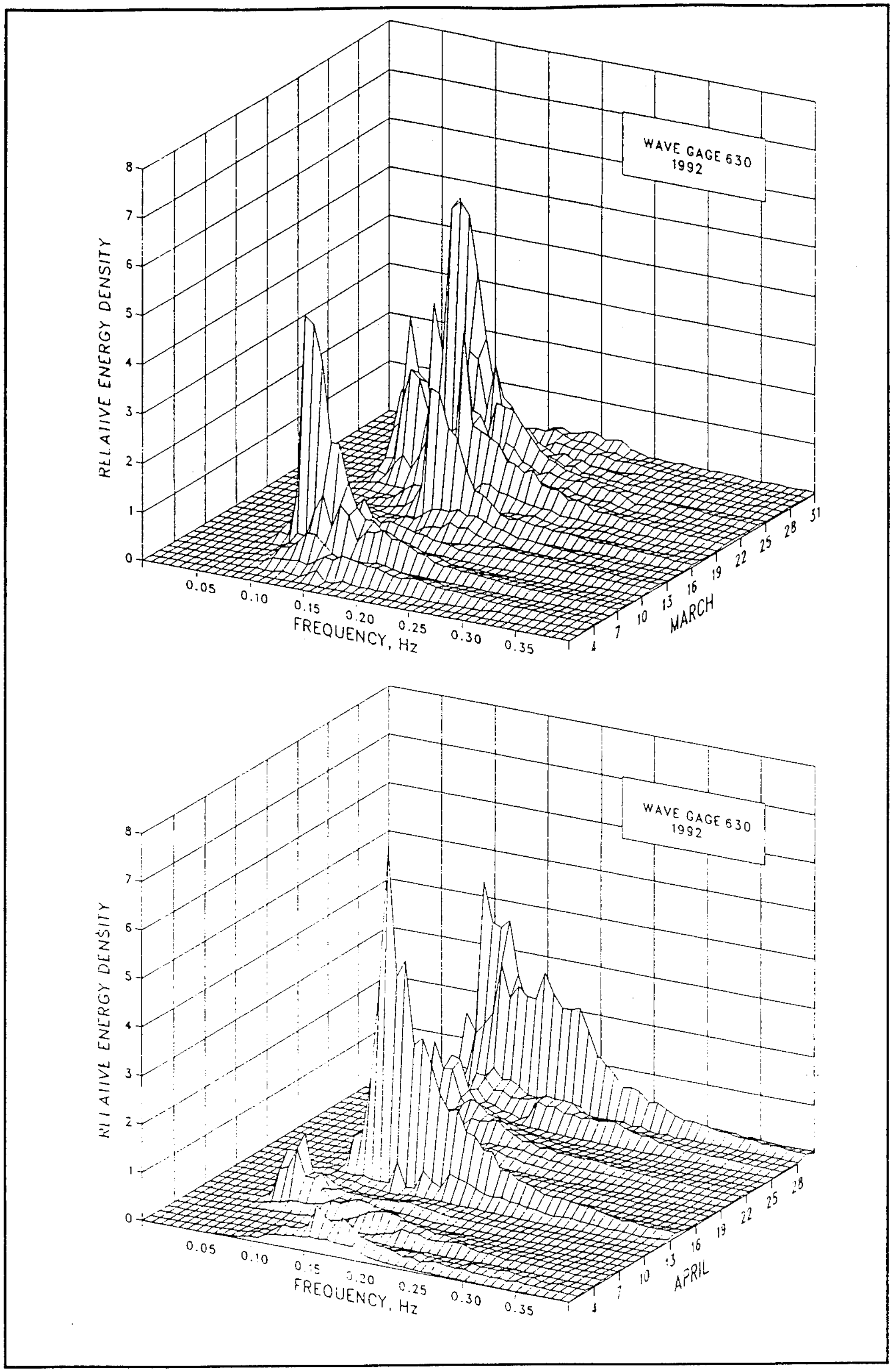


Figure B8. (Sheet 2 of 6)

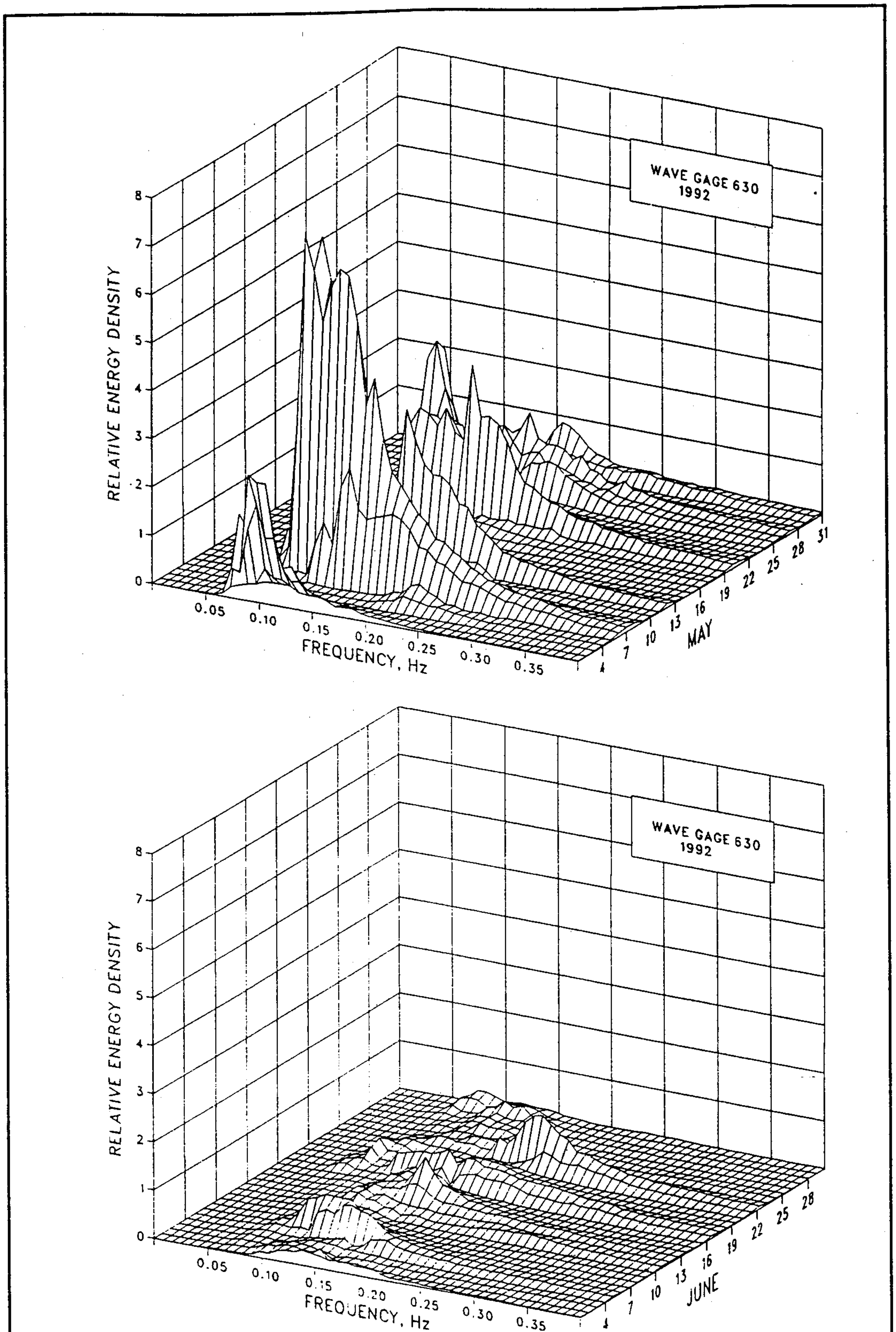


Figure B8. (Sheet 3 of 6)

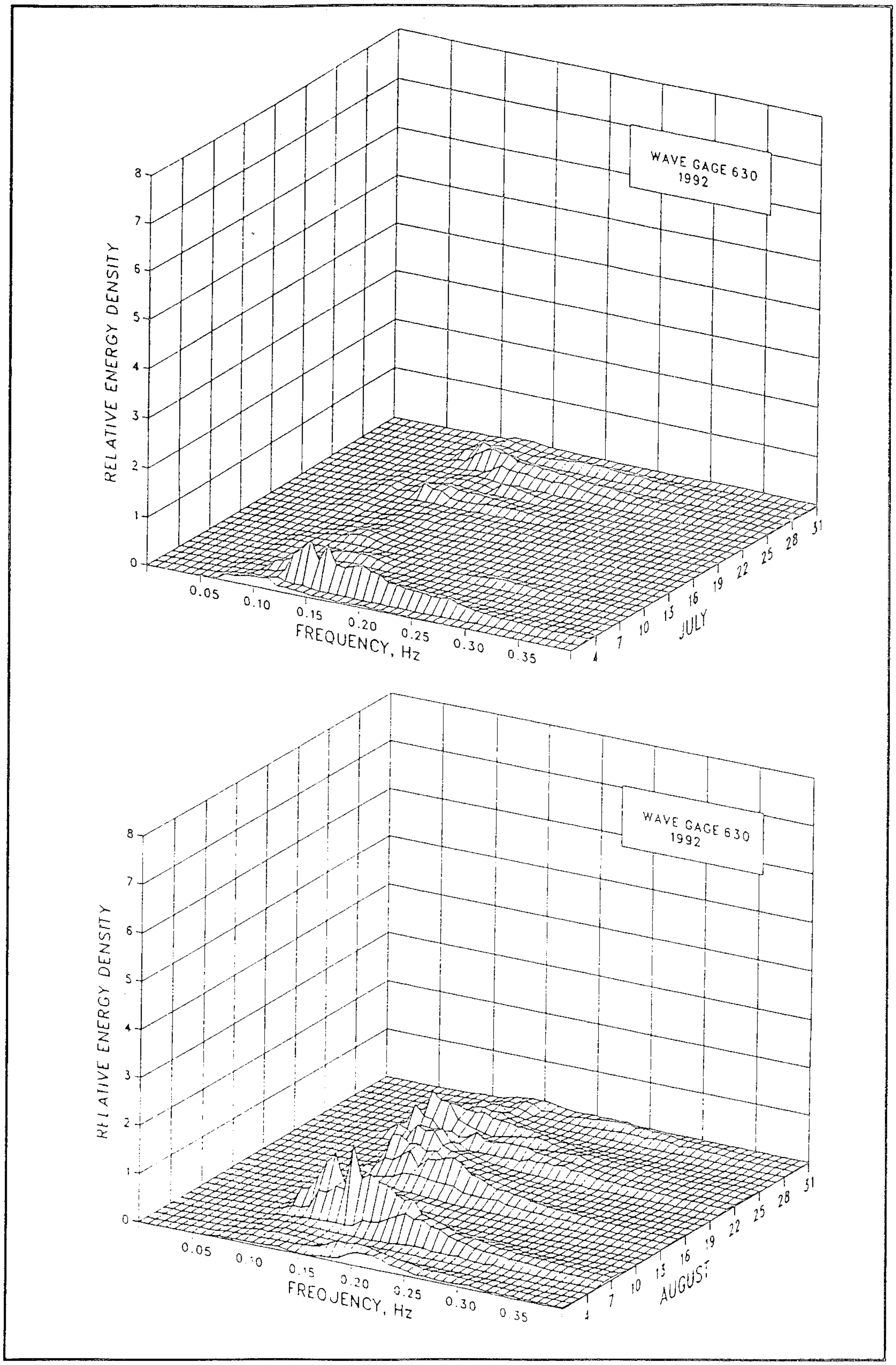


Figure B8. (Sheet 4 of 6)

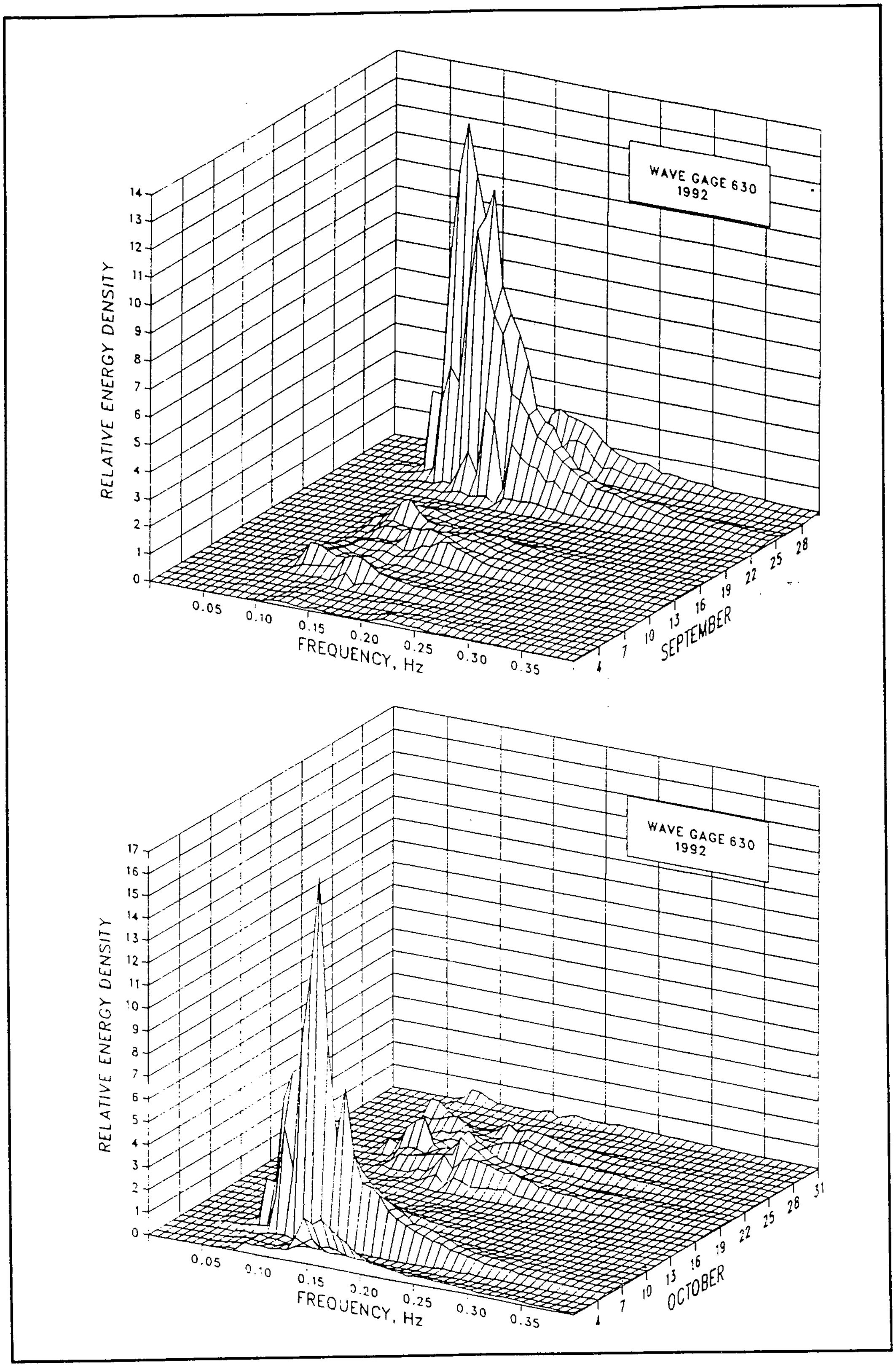


Figure B8. (Sheet 5 of 6)

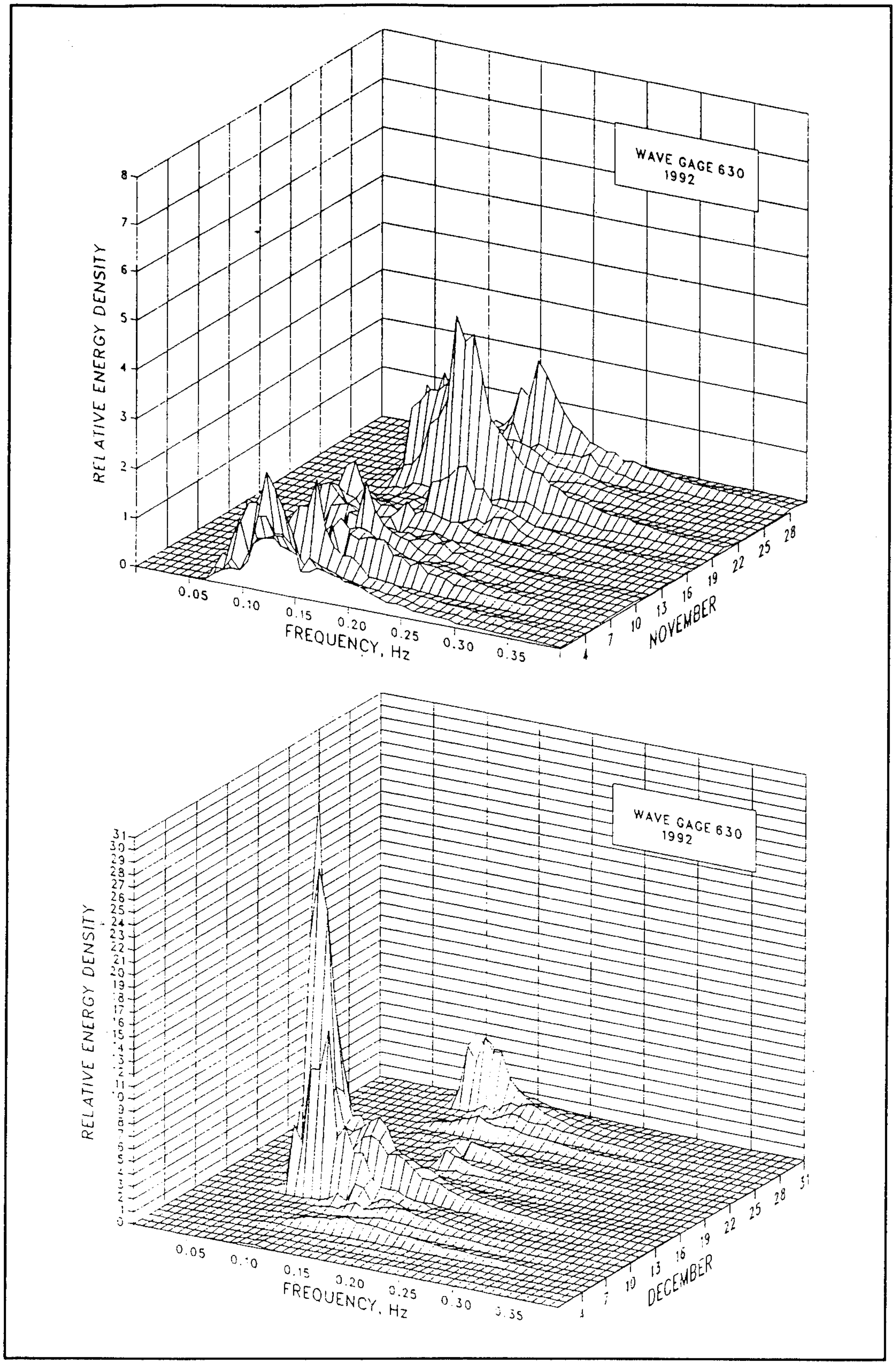


Figure B8. (Sheet 6 of 6)

Table B7
Wave statistics for Gage 630

	1992							1980-1992						
	Height				Period			Height				Period		
Month	Mean m	Std. Dev. m	Extreme m	Date	Mean sec	Std. Dev. sec	Number Obs.	Mean m	Std. Dev. m	Extreme m	Date	Mean sec	Std. Dev. sec	Number Obs.
Jan							0	1.2	0.7	4.5	1983	8.1	2.7	1255
Feb							0	1.2	0.7	5.1	1987	8.4	2.6	1146
Mar	1.2	0.6	3.9	26	8.9	2.5	110	1.2	0.7	4.7	1983	8.7	2.6	1468
Apr	1.1	0.6	3.0	29	8.1	2.6	109	1.0	0.6	5.0	1988	8.5	2.6	1436
May	1.3	0.7	3.5	7	8.6	1.9	114	0.9	0.5	3.5	1992	8.1	2.4	1465
Jun	0.8	0.3	1.4	22	8.5	2.5	115	0.8	0.4	2.7	1991	7.9	2.2	1359
Jul	0.6	0.3	1.5	3	7.5	1.8	114	0.7	0.3	2.1	1985	8.0	2.4	1394
Aug	0.8	0.3	1.6	4	7.5	1.9	111	0.8	0.4	3.6	1981	8.2	2.5	1414
Sep	1.3	0.8	4.2	25	7.8	2.0	107	1.1	0.6	6.1	1985	8.5	2.6	1417
Oct	1.2	0.8	4.2	5	8.9	2.6	120	1.3	0.8	5.4	1991	8.8	2.8	1481
Nov	1.3	0.5	2.3	20	8.4	2.2	120	1.1	0.7	4.6	1991	8.0	2.7	1275
Dec	1.6	1.1	4.4	14	8.8	3.3	120	1.2	0.8	5.6	1980	8.3	3.0	1228
Annual	1.1	0.7	4.4	Dec	8.3	2.4	1140	1.0	0.6	6.1	Sep 1985	8.3	2.6	16338

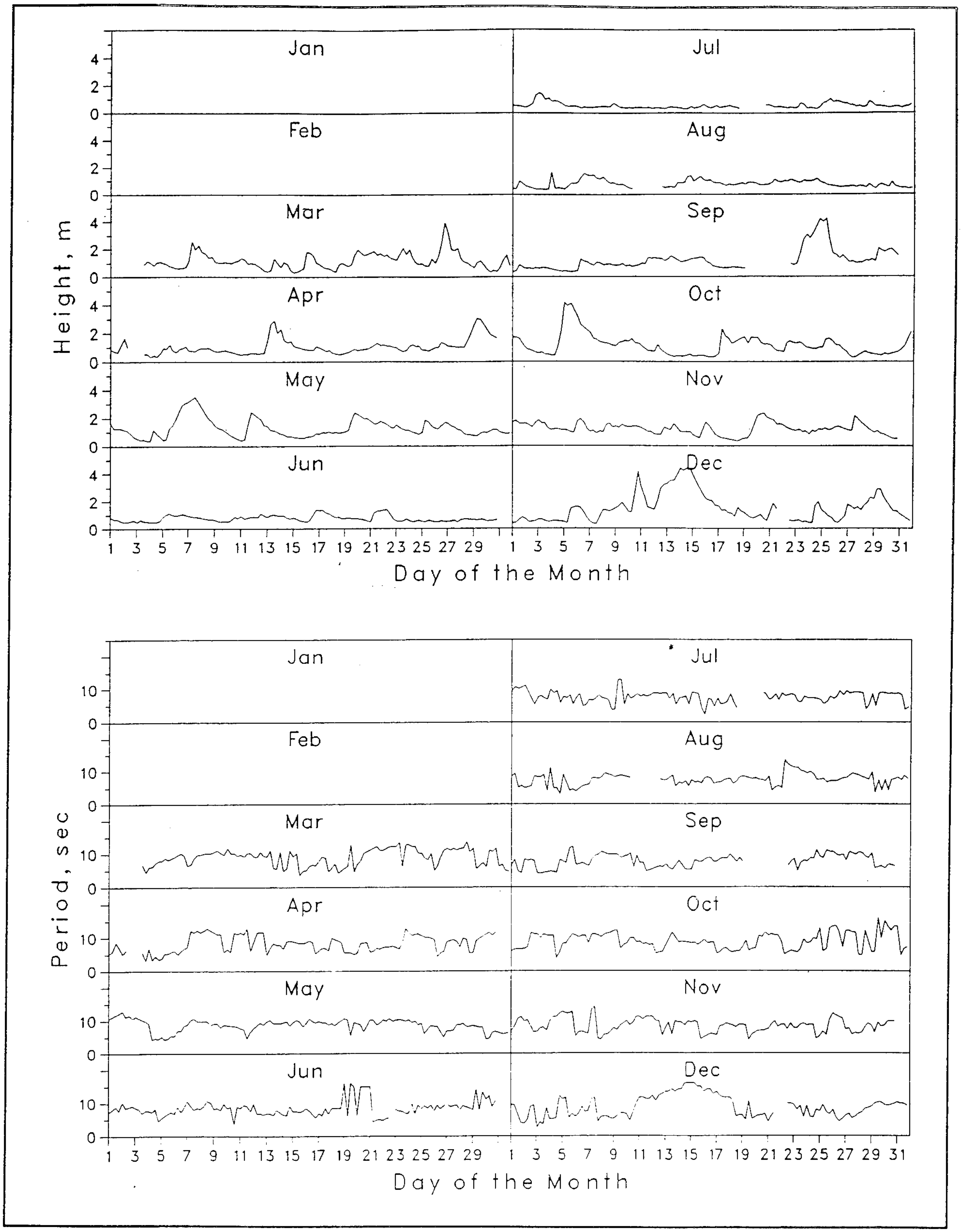


Figure B9. Time-histories of wave height and period for Gage 630

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*

2. REPORT DATE
July 1995

3. REPORT TYPE AND DATES COVERED
Final report in two volumes

4. TITLE AND SUBTITLE
Annual Data Summary for 1992 CERC Field Research Facility

5. FUNDING NUMBERS

6. AUTHOR(S)
Michael W. Leffler, Clifford F. Baron, Brian L. Scarborough,
Kent K. Hathaway, Paul R. Hodges, C. Ray Townsend

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
U.S. Army Engineer Waterways Experiment Station
3909 Halls Ferry Road
Vicksburg, MS 39180-6199

8. PERFORMING ORGANIZATION REPORT NUMBER
Technical Report
CERC-95-10

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
U.S. Army Corps of Engineers
Washington, DC 20314-1000

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES
Available from National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161.

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

This report provides basic data and summaries for the measurement made during 1992 at the U.S. Army Engineer Waterways Experiment Station (WES), Coastal Engineering Research Center's (CERC's) Field Research Facility (FRF) in Duck, NC. The report includes comparisons of the present year's data with cumulative statistics from 1980 to present.

Summarized in this report are meteorological and oceanographic data, monthly bathymetric survey results, samples of biannual aerial photography, and descriptions of 12 storms that occurred during the year. The year was highlighted by a major storm in mid-December which lasted for approximately 7 days. Waves with 4.7-m significant height were measured 6 km from shore.

This report is the 14th in a series of annual summaries of data collected at the FRF that began with Miscellaneous Paper CERC-82-16, which summarizes data collected during 1977-1979. These reports are available from the WES Technical Report Distribution Section of the Information Technology Laboratory, Vicksburg, MS.

14. SUBJECT TERMS
See reverse.

15. NUMBER OF PAGES
123/Vol I; 87/Vol II

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED		

14. (Concluded).

Meteorological research—statistics (LC)
Oceanographic research—statistics (LC)
Oceanographi research stations—North Carolina—Duck (LC)
Water waves—statistics (LC)